UNDER THE RADAR: THE EFFECTS OF COMPUTER GAMES ON INVESTIGATIVE SELF-EFFICACY

A Dissertation

by

YOLANDA ROCHELLE DEBOSE COLUMBUS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2010

Major Subject: Educational Psychology

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Approved by:

Chair of Committee,	Lauren Cifuentes
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ABSTRACT

Under the Radar: The Effects of Computer Games
on Investigative Self-efficacy. (December 2010)

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Chair of Advisory Committee: Dr. Lauren Cifuentes

Minorities are underrepresented in the science workforce yet adequately represented as players of computer games. Findings in career development research suggest that a decision to pursue a science career is directly impacted by a person's investigative self-efficacy. Because minority students choose to spend a significant amount of time playing computer games this study examines the effects of computer games on investigative self-efficacy.

The dissertation is composed of a systematic literature review, the development of a theoretical framework, and an application of the theoretical framework in a quasi-experimental study. In the systematic literature review, the small-to-moderate effect sizes of the 6 systematically identified studies suggest that elements in computer games can potentially affect self-efficacy. Unfortunately, the similarities across the small number of studies makes it difficult to generalize the results to other settings and content areas while variability across the studies makes it difficult to pinpoint which computer game elements or type of computer games affect self-efficacy.

An exploration of theories and empirical research in cognitive psychology, career development, and performance in complex environments led to a theoretical framework. The theoretical framework integrates attention, flow, and self-efficacy theories as well as the results of Berry and Broadbent's (1988) study that compared the effects of implicit and explicit instructions on performance. Using the theoretical framework developed in this dissertation, stealth educational games are proposed as an option for building the investigative self-efficacy of unmotivated or academically struggling learners.

The effect of stealth educational games on minority students' investigative self-efficacy was explored. Based on the statistical results in this study and the differences across each of the schools, the potential value of stealth educational games is still unknown. Future research should employ theory to systematically document and define the context in which the game is delivered, incorporate assessments built into the game instead of using surveys, include incentives for student participation and obedience, and compare the effects of a stealth educational game to an explicitly educational game.

DEDICATION

This dissertation is dedicated to Myia, Jaida, and Daesia -‘da girls’. Stand on my shoulders. Triumph is your destiny, ingrained in your DNA.

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First and foremost, I would like to thank my DADDY who knew I was going to walk this road long before I knew and loved me even when I was running from it. Without HIS presence, guidance, and wisdom this journey would not have been possible and would have been a lot more stressful. So, I thank you LORD for being my DADDY, my COMFORTER, and my SAVIOR.

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CHAPTER I

INTRODUCTION

The science workforce will have a significant impact on our nation's security and economic success; particularly, the innovation and diversity of thought within this workforce. Innovation and diversity of thought is influenced by a myriad of factors, including the diversity of race, cultures, and values, within the workforce. Unfortunately, there is one well-documented area in which this workforce does not reflect diversity; that is diversity of race. Minorities (African-Americans, Hispanics, and Alaska Natives/American Indians) comprise 24% of the United States workforce but only 10% of the college-educated science workforce (NSF, 2002).

Although only a small proportion of minority students choose to pursue science careers, a large proportion of minority students enjoy playing video games (Lenhart, et al., 2008). This behavior suggests that computer games might present a way to increase minorities' interests in science careers. To examine the relationship between computer games and career decisions, the researcher first searched the career development literature to discover what factors influence career decisions. That search yielded identification of two theories regarding career development.

According to theory, career decisions are directly affected by self-efficacy (Betz & Hackett, 2006). Social cognitive career theory (SCCT) suggests that personal variables such as outcome expectations, interest, and self-efficacy effect career choices

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This dissertation follows the style of *International Journal of Gaming and Computer-Mediated Simulations*.

(Lent, Brown, & Hackett, 1994). More specifically, investigative self-efficacy affects choices to pursue science careers. According to Holland's theory of career development, career choices are impacted by the congruence between an individual's personal values and occupational environment (Spokane, 1985; Nauta, 2010)

Holland categorizes personal values and occupational environments into six areas: realistic, investigative, artistic, social, enterprising, and conventional (RIASEC). Self-efficacy is often used to operationally define personal values in Holland's theory. Investigative self-efficacy influences individuals' decisions to pursue science careers (Gwilliam & Betz, 2001; Lent, Larkin, & Brown, 1989). Thus, congruence between investigative self-efficacy and the science work environment suggests that investigative self-efficacy can affect decisions to pursue science careers. A longitudinal study could establish the effects of games on career choice. This study, however, is limited to investigating the effects of computer games on investigative self-efficacy under the theoretical assumption that investigative self-efficacy leads to choosing science careers.

This dissertation examined three questions about computer games and self-efficacy:

- According to published research articles, how do computer games affect self-efficacy?
- According to theory, what type of computer games might affect uninterested learners' investigative self-efficacy?
- How does playing a stealth educational game affect minority students' investigative self-efficacy?

This dissertation is presented in five chapters. Chapter I provides the rationale and purpose of the dissertation, states the expected educational significance of the studies, and provides an overview of the methodologies. Chapter II presents a narrative synthesis of six systematically identified empirical studies that investigate computer games effects on self-efficacy. Chapter III presents a theoretical argument based on three theories and one empirical study that explains why stealth educational games may affect uninterested learners' self-efficacy. Chapter IV presents a study that examines how playing a stealth educational game effects minority students' investigative self-efficacy. Chapter V summarizes findings in the current literature and the implications of the findings as well as provides directions for future research.

The purpose of this dissertation is to gain a deeper understanding of computer games' effects on investigative self-efficacy. Through this exploration, the researcher hopes to influence design principles and product development related to impacting minority students' decisions to pursue science careers. The systematic literature review revealed the limited coverage in the current body of literature while the theoretical argument suggests that sharing learning objectives may not always be appropriate. Finally, the quasi-experimental study results suggest that the type of game had different effects. The effect of an entertainment game was greater or equal to the effect of a stealth educational game on growth in investigative self-efficacy. The quasi-experimental study results also suggest that when playing a stealth educational game the effect of unstated learning objectives is not different from the effect of stated learning objectives on growth in investigative self-efficacy.

CHAPTER II

THE EFFECTS OF COMPUTER GAMES ON SELF-EFFICACY: A SYSTEMATIC REVIEW

Preface

This systematic literature review presents studies related to the effects of computer games on self-efficacy. Of the six systematically identified empirical articles described in this review, five of the articles focus on self-efficacy related to health in college-aged students. Only one of the articles exclusively examined pre-teens and teenagers' health self-efficacy. In addition to the limited content coverage and audience, most of the articles used quantitative research methods. The effect sizes in these studies are small to moderate. Similarities across the small number of studies make it difficult to generalize the results to other populations and settings, and the variability across the studies makes it difficult to determine which computer game elements or approaches to game design impact self-efficacy. Given the limited number of studies on this topic, more research needs to be conducted, and researchers should focus on an uninvestigated population, elementary-aged students rather than college-aged students, in settings other than post-secondary institutions.

Keywords: computer games, self-efficacy, career development, adolescents, digital games

There is a large amount of research on computer educational games and learning. Numerous reviews of this research tout the popularity of the field (e.g., DiPietro, Ferdig, Boyer, & Black, 2007; Van Eck, 2006). Empirical research studies also report on the impact of educational games on learning (e.g., O'Leary, Diepenhurst, Churley-Strom, & Magrane, 2005; Rieber, 1996; Sanford & Madill, 2007; Saxe & Guberman, 1998). Educational games' impacts on learning outcomes, or more specifically the personal experiences during pursuit and achievement of those learning outcomes, is to some extent related to the purpose of this systematic literature review. However, the intention of a systematic review is "to answer a *specific* question" (Petticrew & Roberts, 2006, p. 9). This systematic review strives to discover what the literature says about the effect of computer games on self-efficacy and subsequently focuses on those studies that examined how computer games' affect self-efficacy.

The effect of computer games on player self-efficacy is important because adolescents spend a significant amount of time playing video games, and self-efficacy has a significant influence on career choices (Lent, Brown, & Hackett, 1994). Computer games are defined by the elements in the game (i.e., a narrative story, character development, and risks/rewards), and the game elements define the players' experiences (Salen & Zimmerman, 2004). Because personal experience is a dominant source of self-efficacy (Bandura, 1986; Pajares, 1996), players' experiences during the game may impact the development of their self-efficacy. Self-efficacy is a person's confidence in accomplishing a specific task in a specific domain (Bandura, 1986). If computer game elements impact players' self-efficacy, games may be a viable option in career development programs; this is particularly important in career development programs aimed at workforces that lack racial diversity, such as science.

The model of career choice in social cognitive career theory (SCCT), which forms the theoretical basis for this review, depicts a myriad of factors, including self-efficacy, that impact career choice (Lent et al., 1994). Science self-efficacy is a person's confidence in his or her ability to perform science-related tasks (e.g., exploring, understanding, and searching), and these tasks are vital responsibilities of the science workforce. The science workforce has a direct impact on national security and economic success (Hart & Rudman, 1999). Therefore, if computer games affect science self-efficacy, they can have a positive impact on the science workforce.

Unlike the science workforce, the demographics of computer game players include a variety of races and cultures. On a 2008 survey, 96% of African-American parents, 89% of White parents, and 86% of Hispanic parents indicated that their teens (ages 12–17) played video games (Lenhart et al., 2008). The demographics of the parents (68% White Non-Hispanic; 11.6% Black Non-Hispanic; 14.4% Hispanic; 6% Other Non-Hispanic) reflected the demographics of the U.S. as indicated by "special analysis of the Census Bureau's 2006 Annual Social and Economic Supplement (ASEC) that included all households in the continental United States that had a telephone" (Lenhart et al., 2008, p. 58). On the same survey, according to teens' self-report, 97% played computer (i.e., game console and personal computer) games (Lenhart et al., 2008). Given these statistics, we can conclude that minority teens have a significant amount of experience playing computer games.

Minorities' personal experiences with computer games may provide an opportunity to impact their science self-efficacy using computer games and thus positively impact minorities' decisions to pursue science careers. Although career choices depend on a myriad of factors: personal experience, performance, interests, self-efficacy, and outcome expectations; personal experience has been shown to be a dominant source of self-efficacy and career choices (Lent et al., 2003). The model of career choices in social cognitive career theory, discussed in the following section, outlines the potential effect of personal experience in computer games on career choice.

Model of Career Choices

Career decisions are impacted by a person's interest, choices, and performance (Lent et al., 1994). Accordingly, social cognitive career theory includes three interlocking models—model of interest development, model of career choices, and model of performance—that describe contextual and personal variables that influence career development (Lent et al., 1994). The model of career choices provides the rationale for this systematic literature review.

The model contains three central individual variables- self-efficacy, outcome expectations, and choice goals. Self-efficacy refers to a person's confidence in his or her ability to achieve specific goals in specific domains (Bandura, 1986); while outcome expectations reflect values and an individual's belief about the probability of an outcome; and choice goals refer to an individual's resolve to pursue a course of action.

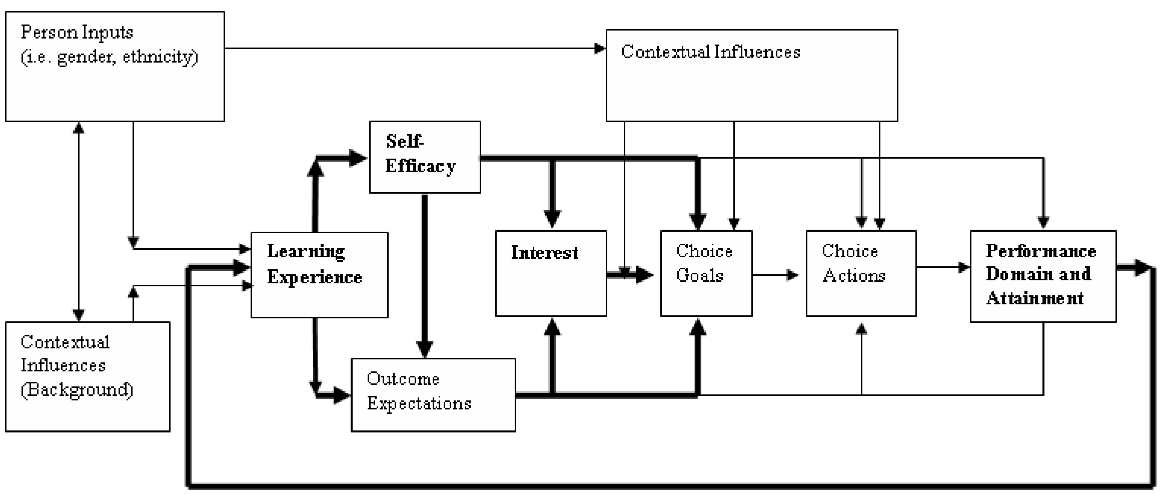
The model of career choices (see Figure 1) suggests that before someone engages in an activity (e.g., choice actions), there must be choice goals related to the activity.

Thus, before a minority student pursues a science career, there must be goals related to science activities. According to the model of career choice, choice goals are impacted by interests. Interest, more specifically career interest, reflects likes and/or dislikes related to occupational activities. Since the development of interest is impacted directly by self-efficacy and outcome expectations, it is safe to say that minority students' science self-efficacy and outcome expectations have a direct impact on their interest in science careers. The relationships among self-efficacy, outcome expectations, and interests suggest that the key to developing minorities' interest in science careers is to increase their science self-efficacy and improve their outcome expectations related to science activities. Both the development of self-efficacy as well as outcome expectations are influenced by a person's learning experience (Lent et al, 1994). In general, repeated successful personal experiences increase self-efficacy and repeated unsuccessful experiences lower self-efficacy. The same is true for outcome expectations.

In addition to the individual variables (i.e. self-efficacy, outcome expectations, and choice goals), there are also a myriad of personal and environmental factors that influence how personal experience affects self-efficacy. For that reason the model of career choice (see Figure 1) also includes paths for personal and contextual variables. The paths for personal and contextual variables serve as precursors to learning experiences and moderators of the relationship between interest and choice actions. The personal variables refer to static traits like gender and ethnicity whereas the contextual variables refer to the environment like support, opportunities, and barriers.

This review focuses on self-efficacy for three reasons based on the model of career choice from SCCT. First, self-efficacy has more direct and indirect influences on choice goals and choice actions (see Figure 1) than other variables in the model of career choices. Second, among the variables in the model, self-efficacy has the most dominant impact on career choices (Bandura, 1986). Finally, computer games provide unique personal experience, and personal experience has a significant impact on self-efficacy. In particular, personal mastery experiences increase self-efficacy (Pajares, 1996).

Figure 1. Model of career choices adapted from Lent et al. (1994). Self-efficacy has a direct influence on five variables: outcome expectations, interest, choice goals, choice actions, and performance domain and attainment. Self-efficacy is directly impacted by learning (or personal) experience.



Computer Games

Computer games provide the opportunities for personal mastery experiences that can have a positive impact on self-efficacy and career choices. Mastery experiences are a common component in today's complex games (Gee, 2003; Prensky, 2005). For example, in complex games, players advance to more difficult levels as they master new skills and abilities (Prensky, 2005).

Computer games are constructed by elements in the game. Game elements define rules that create the player's experience (Rouse, 2005; Salen & Zimmerman, 2004). More specifically, rules create the pleasure, narrative, and social experiences of the player within the game (Salen & Zimmerman, 2004). According to SCCT, personal experiences have a direct impact on the development of self-efficacy. This review will report on the research related to the effects of various computer game elements on player self-efficacy.

Methodology

This chapter describes the effect of computer game elements on self-efficacy using literature published in peer-reviewed journals between 1995 and 2009. The range of publication years was limited to 1995 - 2009 because of the speed and degree of change in technology and video games. This change has impacted the type of digital technology that is available to researchers and potential participants, thereby impacting research design decisions. Some researchers hypothesize that the digital technology also impacted the cognitive development of participants. After deciding to limit the year, the author divided the procedures to complete the systematic literature review into three steps: (1) identifying the articles, (2) applying the article inclusion criteria, and (3) describing the studies.

Article Identification

To identify the articles, the author searched four indexes/databases: Academic Search Complete, ERIC, PsycInfo, and Web of Science (see Table 1). In all four indexes/databases, the author searched using the keyword *game* and self-efficacy*; the asterisk is a wild-card character. Three of the four indexes/databases had different search fields. The author chose search fields that had similar purposes (e.g., subject, topic, and descriptors).

Table 1

Article Identification

Index/Database	Search Term	Field Searched	Number of Articles Identified
Academic Search Complete	Game* and self-efficacy	Subject	7
ERIC and PsycInfo	Game* and self-efficacy	Descriptor	8
Web of Science	Game* and self-efficacy	Topic	59
		Total	74

Article Inclusion Criteria

The goal of the article inclusion criteria was to narrow the articles to empirical studies that included self-efficacy as a dependent variable and included an electronic or computer game as the treatment. The article inclusion criterion was first applied to titles and abstracts (see Table 2). If there was a question about an article, the article was left on the list. Searching the titles and abstracts for studies that included self-efficacy as a dependent variable narrowed the list to 22 articles. The list was narrowed to 10 empirical studies that included electronic or computer games. After applying the inclusion criteria to titles and abstracts, each article was read. As a result of applying the inclusion criteria to titles and abstracts and then to the body of the article, six studies that included computer games and self-efficacy were identified.

Table 2

Article Inclusion Criteria Applied to Titles and Abstracts

No. of Articles Reviewed	**Inclusion Criteria**	**No of Articles Kept**
74	Self-efficacy as dependent variable	22
22	Included electronic or computer game	10
10	Empirical article	10
10	Included electronic game as intervention	10

The six articles identified by applying the inclusion criteria to titles, abstracts, and the body of the article were then characterized using the following factors (see Table 3).

- sample characteristics—sampling technique, total sample size and age,

- theoretical framework,
- dependent variables,
- self-efficacy assessment,
- Cronbach alpha of the self-efficacy assessments,
- treatment,
- analysis, and
- effect size.

The effect size was calculated using Cohen's d and was characterized as small (< .2), medium (.2 through .6), or large (> .7).

Results

The final sample of six studies provides empirical evidence to describe the effect of computer games on player self-efficacy. Two of the studies were published in 1997, two in 2008, and two in 2009. The studies are discussed across six attributes: sample, dependent variables, data collection schedule, game elements, game design, analysis, and self-efficacy assessments.

Table 3

Profile of Six Systematically Identified Articles

Authors	Yr	Sampling Technique	Sample Size (age range)	Theoretical Framework	SE Dependent Variables	SE Assessment	Cron-bach Alpha	Treatments	Analysis	Effect Size
Brown; Liebarman; Gemeny; Fan; Wilson; Pasta	1997	Volunteer selection and Random assignment	59 (8-16 yrs)	Game-playing; Self-concept; Social support; Knowledge; Self-care; Health outcomes	Self-efficacy for managing diabetes; Seeking advice; Communication; Information; Skills; Curiosity; Diet; Self-monitoring; Medications; Health outcomes	11 seven-point Likert-scaled items (created)	*Not reported*	Packy & Marlon Nintendo Game (Trt); Commercial Nintendo Game (C)	Unpaired t-tests	0.19
Thomas; Cahill; Santilli	1997	*Unclear*	324 (12 - 22 yrs)	Self-efficacy theory; Health education theory	High-risk adolescents response to game; Behaviors; Approaches to negotiating safer sex; Knowledge; Self-efficacy about negotiating safer sex; program implementation	4 four-point Likert scaled question (created)	0.86	Life Challenge Computer Game (Trt)	Paired t-test	0.12
Peng	2008	Volunteer selection and Random assignment	80 (Undergraduates)	Social Cognitive Theory	Healthy-eating self-efficacy	14 items (adapted)	0.87	Play Computer Game (Trt); Observe Computer Game being played (C)	Regression	0.23[a]

Table 3 cont.

Authors	Yr	Sampling Technique	Sample Size (age range)	Theoretical Framework	SE Dependent Variables	SE Assessment	Cron-bach Alpha	Treatments	Analysis	Effect Size
Kato; Cole; Bradlyn; Pollock	2008	Volunteer selection and Random assignment	371 (13-29; 66% <16)	Video game based learning	Adherence; Perceived self-efficacy to manage cancer and its treatment; Knowledge; Control; Stress; Quality of Life	27 seven-point Likert-scaled items (created)	0.93	Re-mission Computer Game + Commercial Computer Game (Trt); Commercial Computer Game (C)	Repeated measures mixed 2 X 3 ANOVA	0 .03
Behm-Morawitz; Mastro	2009	Volunteer selection and Random assignment	328 (Undergraduates)	Social Cognitive Theory	Self-esteem; Self-efficacy; Gender attitudes and beliefs	General Self-efficacy Scale	0.79	Sexualized Female Character in Computer Game (Trt1); Non-sexualized Female Character in Computer Game (Trt2); No Computer Game (C)	ANOVA and MANOVA	-0..45
Peng	2009	Volunteer selection and Random assignment	40 (Undergraduates)	Social Cognitive Theory: Health belief mode	Behavior; Healthy-eating self-efficacy; Perceived benefits; Perceived barriers; Behavior change intentions	14 seven-point Likert scaled items (adapted)	.88	Rightway Computer Game (Trt); No game (C)	ANCOVA	.59

a. Converted to Cohen's d using the following formulas: t = Beta/SEB and d = 2t/df.

Sample

The sampling technique was the same across five of the six studies; each utilized volunteer selection and random assignment to assign participants to treatment groups. There were a total of 1,202 participants with sample size ranges from 59 to 371. The majority of the participants were undergraduate or college-age students. Three of the six studies included only undergraduate students (Behm-Morawitz & Mastro, 2009; Peng, 2008, 2009), two studies included both adolescents and college-age students (Thomas, Cahill, & Santilli, 1997; Kato, Cole, Bradlyn, & Pollock, 2008), and one included only adolescents (Brown et al., 1997).

Only a few of the studies reported additional demographics such as ethnicities and gender. Only two of the six studies reported the percentage of minorities, whites, and other ethnicities (Thomas, Cahill, & Santilli, 1997; Kato, Cole, Bradlyn, & Pollock, 2008). These two studies included a total of 695 participants. Fifty one percent of these participants were minorities, 40% were white, and 9% were other. Virtually all of the studies, five out of the six, reported percentage of male and females. Together these five studies included 1143 participants. Fifty-six percent of these participants were male and 44% were female.

Across the six studies, participants represented 64 academic and community institutions. Participants from four of the six studies were each a part of one academic institution such as a university or academic medical center (Behm-Morawitz & Mastro, 2009; Brown et al., 1997; Peng, 2008, 2009). Participants in the other two studies were from multiple institutions: Participants in the study by Kato et al. (2008) represented participants from 27 academic medical centers in the United States, six academic medical centers in Canada, and one academic medical center in Australia. Participants in the study by Thomas et al. (1997) represented two group homes, two job corps sites, two rehabilitation centers, and two community-based organizations in New York. The study by Thomas et al. (1997) was the only one that included institutions that were not affiliated with a university or academia.

Dependent Variables

Five of the studies examined the effect of computer game on health-related self-efficacy (Brown et al., 1997; Kato et al., 2008; Peng, 2008, 2009; Thomas et al., 1997), and one focused on general self-efficacy (Behm-Morawitz & Mastro, 2009). Three of the five studies that focused on health-related self-efficacy examined self-efficacy related to preventing or managing diseases such as HIV, cancer, or diabetes (Brown et al., 1997; Kato et al., 2008; Thomas et al., 1997). The other two studies examined health-related self-efficacy associated with managing healthy eating (Peng, 2008, 2009).

Data Collection Schedule

The data collection schedule and time spent playing the games in each study varied. In two of the studies, data was collected before the study began and then at three-month intervals (Brown et al., 1997; Kato et al., 2008). In three studies, data was collected before the study began and then after 30–40 minutes of game play (Behm-Morawitz & Mastro, 2009; Peng, 2008, 2009). In one study, data was collected throughout one session of game play (Thomas et al., 1997).

In the two studies that collected data at three-month intervals, one collected data after 1 three-month interval, and the other collected data after 3 three-month intervals. In the study in which data was collected at the end of 1 three-month interval, participants averaged 7.7 hours of game play (Kato et al., 2008). Participants in the other study averaged 18, 16, and 16 hours of game play across each three-month interval, respectively (Brown et al., 1997).

Research Design

The research designs and effect sizes varied across the six studies. Five of the studies utilized both experimental and control groups. In three of those five studies, results from the treatment groups were compared to the results from the control groups that *did not* play a computer game (Behm-Morawitz & Mastro, 2009; Peng, 2008, 2009). In those three studies, the effect sizes were small to moderate: .22, .45, and .59. In the other two studies, which included a control group that *did* play a computer game, the effect sizes were small: .02 and .19 (Brown et al., 1997; Kato et al., 2008). The effect size of the one study that only used a pre- and post-test was also small: .12 (Thomas et al., 1997).

Game Elements

As mentioned previously, player experience is defined by the computer game elements included in the game. The computer games in the six reviewed studies included a variety of elements (see Table 4). The common game element across all six studies was interactivity; meaning that the player's experience depended on the player's choices. Four of the studies included role-playing, which means that the player experienced the game as a character defined in the game (Brown et al., 1997; Peng, 2008, 2009; Thomas et al., 1997). Two of the studies included simulation in which the game world mimics the real world (Peng, 2008, 2009). There were six elements that were unique to each of the six different studies: 3-dimensional graphics, characters don't die, character promiscuously dressed, narrative story, competition, and challenge.

Table 4

Game Elements Included in the Six Studies

	Brown, Lieberman, Gemeny, Fan, Wilson, & Pasta	**Thomas, Cahill, & Santilli**	**Peng**	**Kato, Cole, Bradlyn, & Pollock**	**Behm-Morawitz & Mastro**	**Peng**
Publication Year	1997	1997	2008	2008	2009	2009
Game	Packy & Marlon	Life Challenge	Mediated Enactive Experience	Re-mission	Tomb Raider	Rightway Café
<u>Game Elements</u>						
Interactive	X	X	X	X	X	
Role-playing	X	X	X			X

Table 4 cont.

	Brown, Lieberman, Gemeny, Fan, Wilson, & Pasta	**Thomas, Cahill, & Santilli**	**Peng**	**Kato, Cole, Bradlyn, & Pollock**	**Behm-Morawitz & Mastro**	**Peng**
Simulation			X			X
Three dimensional				X		
Characters don't die				X		
Character promiscuous-ly dressed					X	
Narrative Story						X
Competition						X
Challenge						X

Game Design

Each of the researchers who conducted the six studies either developed a game specifically for their study or used an existing game; each attributed their decisions to different theoretical frameworks. In four of the six studies, researchers developed a game specifically for the study (Brown et al., 1997; Kato et al., 2008; Peng, 2008; Thomas et al., 1997). The other two chose an existing game (Behm-Morawitz & Mastro, 2009; Peng, 2009). Of the four studies for which a game was developed, three were based on theory, including social cognitive, video game-based learning, and/or health behavior theories (Brown et al., 1997; Kato et al., 2008; Peng, 2008); for the fourth study, researchers developed a game based on focus groups (Thomas et al., 1997). Of the two studies for which an existing game was chosen, one based it on a pilot study (Behm-Morawitz & Mastro, 2009), and the other based it on social cognitive theory and the health belief model (Peng, 2009).

Analysis

The six studies used four different statistical analyses: t-tests, analysis of variance (ANOVA), analysis of covariance (ANCOVA), and regression. Three of these four analyses compared means across groups (e.g., t-tests, ANOVA, and ANCOVA) and the other examined the effects of computer games on self-efficacy (e.g. regression).

Self-Efficacy Assessments

Five of the six articles created a self-efficacy assessment specifically for their study. Only one of the five referenced Bandura's recommendation for constructing a self-efficacy scale (Kato et al., 2008). The other four did not discuss the process for constructing the self-efficacy assessment. The only study that used a previously developed assessment measured general self-efficacy (Behm-Morawitz & Mastro, 2009). Five of the six studies reported high Cronbach alphas (.79–.92).

Discussion

Although the small-to-moderate effect sizes of these six reviewed studies suggest that computer games have the potential to impact self-efficacy, similarities across the small number of studies make it difficult to generalize the results to other populations and settings, and the variability across the studies makes it difficult to determine which computer game elements or approaches to game design can impact self-efficacy. As a result of the small number of studies and the variability across the six studies, the author could not conclude that computer games in general, nor specific elements in computer games, affect self-efficacy. Instead, the characteristics of the six studies helped the author make suggestions for future research. The limited age group in the aforementioned six studies led the author to conclude that future research should include elementary-aged students or older adults. The limited content area led the author to conclude that future research should cover a different content area.

Participants and Setting

Participants in the six reviewed studies were primarily college-aged students. Consequently, the results of these studies could inform the design of computer games for traditional college-aged students but say nothing about the design of computer games for older students, adolescents, or elementary age students. Additionally, data from most participants were collected through organizations associated with post-secondary education institutions; this limits the setting in which the results may be valid. For instance, the staff and resources that are available to the organizations in these six studies may be different from local community programs; thus, the results may not be generalized to local community programs.

The six reviewed studies do not include a diverse group of participants or variety of contexts. Instead five of the six studies are conducted in similar contexts with participants of similar age. In order to generalize to different contexts, future research should examine the effect of computer games on self-efficacy with a different population in a different context, such as adolescents in local community programs.

Data Collection Schedule and Approach to Game Design

The schedule for data collection and approach to game design varied across all six studies. Some participants played a game for 30 minutes on one day and were then assessed, while others played a game an average of 18 hours across 90 days before they were assessed. Furthermore, decisions for game design were based on a variety of theories. The author could not determine if the amount of game playing, the approach to game design, or the game itself impacted the development of self-efficacy.

Iterative refinement allows researchers to assess the impact of minor selective changes in research design. Only two of the studies used an iterative approach to make design decisions (Peng, 2008; 2009). As a result of the random variability in the reviewed studies, any real-world decisions about amount of game play or game design based on these studies would not be evidence-based. To investigate how the amount of game playing and game design affects self-efficacy, future research should employ both systematic and iterative refinements of design, development, and evaluation processes.

Validity

Although five of the six studies addressed reliability (e.g., Cronbach alpha ranges .79–.92), none of the six articles included a discussion about the validity of the data or the conclusions. Without this discussion, the soundness, implications, and accuracy of the results and conclusions may be questionable. Systematic validity implies that the research and conclusions drawn from the results inform the questions that guided the research (Hoadley, 2004). In design-based research, systematic validity is supported by using the same person to employ theory to design an intervention, implement the intervention, and measure the outcomes of the intervention. An essential component to this process is a detailed description of the potential ways the researcher’s philosophy or aspirations may impact the results. None of the six reviewed studies included a detailed description of the researcher’s potential biases or aspirations. In order to decisively inform research and practice, future research should include a description of the researcher's agenda.

Conclusions

The small-to-moderate effect sizes suggest that elements in computer games can potentially affect self-efficacy. Unfortunately, details about the relationship between computer games and self-efficacy cannot be defined by the current literature. If future researchers want to describe computer games' effects on self-efficacy, their research should be guided by the methodologies and strategies in design-based research. In accordance with these principles and the six reviewed studies, future research studies should include adolescents in local community programs, hold amount of game-playing time constant, and vary type of games played, plus document and report a detailed description of a researcher's potential bias and aspirations.

CHAPTER III

A THEORETICAL ARGUMENT FOR STEALTH EDUCATIONAL GAMES

Preface

By integrating three theories—attention theory, flow theory, and self-efficacy theory—as well as the results from one empirical study that reported the positive effects of implicit instruction over explicit instruction, the author makes the case for using stealth educational games. This article addresses the problems of games that are neither entertaining nor educational because their explicit objectives interfere with learner engagement. Based on the theoretical argument, stealth educational games are defined by four attributes, one of which is that stealth educational games prepare learners to function in multivariate systems. Such systems replicate authentic science environments and, therefore, might increase investigative self-efficacy. Playing stealth educational games is proposed as a strategy for building the investigative self-efficacy of unmotivated or academically struggling learners.

The purpose of this article is to make a case for using stealth educational games to increase investigative or science self-efficacy in students who are academically unmotivated. Increasing self-efficacy is important because according to social cognitive career theory (SCCT) self-efficacy affects career choices (Lent, Brown, & Hackett, 1994). More specifically, investigative self-efficacy affects choices to pursue science careers (Gwilliam & Betz, 2001; Lent, Larkin, & Brown, 1989). Thus, the first step in impacting career decisions is to influence self-efficacy.

The author makes the case for using stealth educational games to increase investigative self-efficacy by integrating three theories: attention theory, flow theory, and self-efficacy theory, as well as the results from one empirical study; the empirical study presents an investigation of the comparative effects of explicit and implicit learning experiences. This article also suggests how stealth educational games might address the viewpoint that games that are explicitly educational (rather than stealthy) are sometimes neither engaging nor educational. This viewpoint has been firmly acknowledged by numerous experts in the field (e.g., Chen, 2007; Gee, 2003; Van Eck, 2006).

Although explicit learning objectives are thought to be core elements of effective instruction (Morrison, Ross, & Kemp, 2004), the enduring achievement gap between various races and socioeconomic levels indicates that designers may need to rethink conventional instructional design practices (Lee & Wong, 2004). The enduring achievement gap can be attributed to a variety of reasons related to politics, economics, or instruction. Instructional designers should consider that effective instruction may also employ implicit learning objectives. While instructional design practices in the United States have focused on making learning objectives explicit for the past 30 years (Marzano, 1998), for over 3,000 years, cultures in the East have used implicit learning objectives to teach history and values (e.g., parables). For example, the Bible, which originated in the East, is one of the oldest and most widely read books that utilizes implicit learning objectives. This article presents a rationale for using implicit learning objectives rather than explicit learning objectives in science educational games to improve science self-efficacy for students who are unmotivated or struggling in traditional science class.

In today's era of accountability and standard-based assessment, explicit learning objectives have become commonplace in science curricula (Scruggs & Mastropieri, 2007). Unfortunately, this approach has not had the anticipated positive impact for all groups of learners (e.g. different disability levels, races, and socioeconomic levels; Lee & Wong, 2004; Scruggs & Mastropieri, 2007). In an effort to improve the impact of explicit learning objectives and take advantage of the strengths of games, some educators and game companies developed edutainment games (Van Eck, 2006), including educational science games. Regrettably, educational games still do not have a positive impact on students' performances on standard-based assessments (Gee, 2003; Van Eck, 2006). The reason for the mediocre impact may be because all too often, educational games are neither entertaining nor educational (Papert, 1998).

Explicit learning objectives are typically used in edutainment games. Learning objectives and tasks are not seamlessly integrated into edutainment games; instead, learning is at the forefront, the game mimics the structure of classroom lessons, and fun is an afterthought. These educational games are similar to grape-flavored cough syrup. Although you can taste the grape flavor, there is no doubt that it is cough syrup. When students are playing edutainment games with stated learning objectives, they have no doubt that the games are educational. Hereafter, the terms *educational games* and *edutainment* will be used interchangeably.

In contrast, implicit learning objectives are used in stealth educational games. Stealth educational games are defined here based on four attributes:

1. primarily focus on entertaining the player,
2. do not inform players of learning objectives,
3. seamlessly integrate tasks that support the learning objectives in game play, and
4. require players to apply complex rules in multivariate systems.

Each of the four attributes impacts students' personal experience. Attribute one contributes to engaging today's adolescents. Attributes two and three contribute to engaging unmotivated students or students who struggle academically by hiding the educational aspects of the game. Attribute four is related specifically to science. It adheres to the National Assessment of Educational Progress' (NAEP) recommendation for what students should know about systems in science: "Students should be able to identify and define the *system* boundaries [e.g., know the rules], identify the components [e.g., multiple variables] and their interrelationships [e.g., complex relationships], and note the inputs and outputs of the *systems* [e.g., know and apply the rules]" (O'Sullivan

& Weiss, 1998, p. 309). When a stealth educational game involves skills associated with science, players' personal experiences with the game can impact their science self-efficacy.

Attention, flow, and self-efficacy theory as well as an empirical study conducted by Berry and Broadbent (1988) together provide a rationale for using stealth educational games to increase students' science self-efficacy. The rationale is discussed by supporting the aforementioned concerns through the integration of the three theories and results from Berry and Broadbent's (1988) study. The presentation of this rationale begins with a description of the attention, flow, and self-efficacy theories as well as Berry and Broadbent's (1988) study. The description is followed by an explanation of how these theories support two commonly held views. The rationale ends with the integration of the three theories and the Berry and Broadbent study. Although other implicit learning studies compare the effect of implicit and explicit instructions on performance, the tasks in these other studies do not resemble the complex multivariate systems found in science environments. Thus, they are not reported in this framework.

Attention Theory and Games

Attention theory describes the cognitive processes people use to acquire knowledge from external (e.g., physical environment) and internal (e.g., mental representation) sources (Sheridan, 2007). Cognitive processes that direct attention depend on characteristics in the environment that are retrieved using the senses (e.g., sight, touch, smell, taste, sound) and also on personal intentions and goals.

Attention was originally thought to be a one-dimensional construct that allowed people to filter information (Broadbent, 1958). Currently, attention is viewed as a multi-dimensional construct involving selective, focused, divided, and sustained attention (Wickens, 2007). Selective attention in the multi-dimensional model is very similar to the original view of attention; it is the process of continuously selecting and switching between elements in physical and mental environments (Wickens, 2007). Attention can also be voluntary or involuntary (Sheridan, 2007). When voluntary selective attention becomes involuntary, it automatically impacts a person's behavior during required educational activities (e.g., science class) and optional entertainment activities (e.g., games, like Mario Kart®).

The selective attention construct depicts how humans focus on relevant information and disregard irrelevant information (Wickens, 2002). What information a person chooses to selectively attend to depends on characteristics that are internal (e.g., goals, values, priorities) and external (e.g., color, volume, location) to a person. For example, in car-racing computer games like Mario Kart®, the player's internal goal may be to win without crashing. To accomplish this goal, the player must choose to pay attention to the external environment (e.g., banana peels on the track, other cars on the track, and buttons on the joystick). Identifying which game elements automatically gain the attention of game players and inserting those elements in science education games may increase student concentration during science education games.

Voluntary attention progresses to involuntary attention through repeated practice (Matlin, 2005; Plude, Enns, & Brodeur, 1994; Schneider & Shiffrin, 1977). Involuntary attention always activates specific sequences of mental events without the individual actively controlling or attending to information (Pashler, Johnston, & Ruthruff, 2001; Schneider & Shiffrin, 1977). Games can provide repeated practice of real-world skills. For example, an avid player of Mario Kart® posted the following on her Facebook page: “While driving [her real car] yesterday I saw a banana peel in the road and instinctively swerved to avoid it.....thanks Mario Kart” (Marcel, 2010). Subsequent comments and conversations on her Facebook page indicated that she truly swerved to avoid a banana peel on the road.

According to attention theory, repeated practice has two consequences: (1) specific sequences of mental states are automated, and (2) a person’s behavior and expectations are guided by specific prior experiences such as playing computer games. These mental states and experiences are defined by situational attributes that define the environment. The environment or situational attributes also play an important role in flow theory.

Flow Theory and Games

Flow is a theory of the optimal experience (Csikszentmihalyi, 1990). Optimal experiences are defined by how they make people feel; they generate a “deep sense of enjoyment that is long cherished and that becomes a landmark in memory for what life should be like” (Csikszentmihalyi, 1990, p. 3). These optimal experiences occur when humans push beyond their mental and/or physical abilities while trying to conquer an obstacle or overcome a challenge. Multiple optimal experiences throughout people’s lives amount to a sense of control, a sense of mastery.

When humans encounter an optimal experience, they experience flow (Csikszentmihalyi, 1990). Flow is a “state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it” (Csikszentmihalyi, 1990, p. 4); the activity is intrinsically rewarding. Games are one of the few activities that consistently produce flow. Games are typically purposefully designed to help people achieve the optimal flow experience, to give that deep sense of enjoyment.

The optimal flow experience offers unique opportunities for personal growth through sustained focused attention and loss of self-consciousness (Csikszentmihalyi, 1990). In some activities that consistently produce flow, such as sports and games, the player is placed in a world where risks and rewards are mitigated. This alternate reality creates new opportunities for exploration and pushes the person to achieve and perform at advanced levels (Csikszentmihalyi, 1990).

Situational attributes lead to the *flow state*. The flow state includes:

- feelings of immersion,
- a merging of awareness to current actions,
- a high degree of concentration,
- self-confidence, and
- feelings of control (Eccles & Wigfield, 2002).

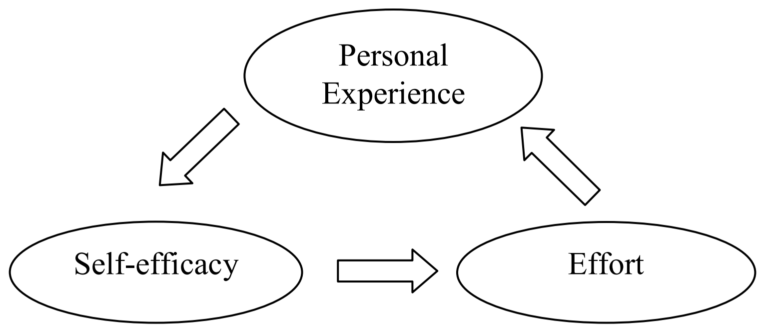
To achieve the flow state, the level of challenge must appropriately match the level of required skill; as a result, individuals are motivated to continue (Csikszentmihalyi, 1990). Integrating attention theory principle (i.e. that a person’s behavior and expectations are guided by specific prior experiences) one can argue that prior experience with flow impacts expectations during specific activities, such as playing computer games. Playing computer games are personal experiences which effect self-efficacy.

Self-efficacy Theory and Games

Bandura (1986) defines self-efficacy as an individual's belief in his or her ability to accomplish a task successfully. Self-efficacy is also domain specific and may not transfer to other domains (Bandura, 1986); thus, children who have high computer game self-efficacy may have low science self-efficacy. Domain and context are defined by attributes of the environment and the activity. Two roles of educators are to build self-efficacy in individuals and to help them transfer self-efficacy from one domain to another.

Self-efficacy develops as a result of personal experience, observation of others, feedback, and skill acquisition (Bandura, 1986). Bandura (1986) argues that personal experience has the most significant influence on self-efficacy. A positive personal experience, or mastery experience, directly increases self-efficacy, and in turn, self-efficacy directly impacts effort (Bandura, 1986; Pajares, 1996). For instance, a person with low science self-efficacy will hesitate to expend effort during challenging science tasks and many times will choose to completely avoid the task. However, a person with high science self-efficacy will expend effort toward science tasks, and those tasks will sustain that learner's attention. The circle is complete when effort directly impacts personal experience (see Figure 2). Little effort may create a negative personal experience; high effort may create a positive personal experience. For struggling or unmotivated learners, the circular relationship between personal experience, self-efficacy, and effort may reinforce low self-efficacy in a number of arenas. However, when those same struggling learners have high self-efficacy in gaming, as so many do, they are willing to expend effort and build further personal experience in games.

Figure 2. Circular relationship between personal experience, self-efficacy, and effort.



Through repeated practice and practice variability, self-efficacy is generalized (Holladay, & Quiñones, 2003; Pugh & Bergin, 2006). Practice variability implies that the attributes of the environment and activity change as a person practices. As in science, stealth educational games include complex systems with interrelationships between multiple variables. The complex system and interrelationships provide opportunities for variability. Through repeated practice and practice variability, self-efficacy developed in the stealth educational game should generalize to similar environments, such as science environments that include complex multivariate systems.

Generalizations in self-efficacy depend on self-knowledge that comes to mind in various situations and settings (Cervone, 2000). Thus, through practice variability in games that include complex systems that, by NAEP definition, mirror authentic science tasks, self-efficacy in the game may generalize to similar tasks outside of the game.

Integrating these three theories discussed above provides a rationale for using stealth educational games to increase science self-efficacy. Games sustain the voluntary attention of young learners. Through repeated practice, that voluntary attention progresses to automaticity, which can transfer to real-world tasks. Additionally, players often experience flow while gaming. Flow increases their motivation to game more and provides them with positive personal experiences. Positive personal experiences in complex multivariate systems, such as games, increase self-efficacy regarding those systems, which then increases players' effort. The positive personal experience, self-efficacy, and effort related to performing in complex systems should transfer to science tasks. The transference may be impacted by a myriad of other factors such as the environment in which the tasks are performed or the motivation of the individual.

Empirical Study: Implicit Versus Explicit Learning

During implicit learning, a learner must unconsciously acquire knowledge; a learner must acquire new concepts, not merely facts; and a learner must not have the ability to completely verbalize that knowledge (Seger, 1994). Implicit learning should not be confused with incidental learning. The distinction between implicit and incidental learning is important because the classification characterizes the process of acquiring knowledge, the type of knowledge acquired, and the result of acquiring the knowledge.

Unlike implicit learning, during incidental learning, the learner can either consciously or unconsciously acquire new knowledge, a learner can acquire new concepts and new facts, and a learner can verbalize the knowledge.

Reber initiated investigations into the effects of implicit learning due to the concern that explicit instructions may hinder learning (French & Cleeremans, 2002; Seger, 1994). The body of research about implicit learning has implications for the use of implicit versus explicit learning objectives in games:

> . . . it seems clear that any number of confounding factors may influence, either positively or negatively, the impact of *explicit instructions*. Such instructions may introduce an element of stress or anxiety, they may evoke a sense of motivation to succeed on the task, encourage one or another conscious strategy, and the like. (Reber, 1993, p. 50)

Similar to explicit instructions, explicit learning objectives may initiate stress, suppress enthusiasm, or encourage a particular strategy that negatively affects personal experience. Therefore, for unmotivated learners, implicit learning objectives may be more effective than explicit learning objectives.

Explicit learning objectives are thought to be a core component of effective instruction (Smith & Ragan, 2005). It is argued that sharing the learning objectives prepares the learners to learn and can help learner's recall prior related knowledge. Recalling prior knowledge will help learns situate the new knowledge. This view is seen in many instructional design practices such as Gagne's Nine Events of Instruction. However, research suggests that withholding the learning objectives from the learner may also be appropriate. This is built on the premise that learners prior experience influences what they learn and how the learn.

Each learner has unique experiences and views that affect cognitive development. According to constructivist, the individual experience of each learner impacts their knowledge acquisition. This philosophy is supported by the findings in a meta-analysis conducted by Marzano (1998). The effect sizes reported in Marzano's (1998) meta-analysis suggest that creating and sharing highly specific learning objectives is less effective than allowing students to determine learning objectives. Based on these results, perhaps it is more effective to share general instructions and allow students to determine their individual learning goals (Marzano, 1998).

These results challenge the objectivist view which holds that the purpose of the mind is to mirror the well-structured world and that the goal of instruction is to transfer that structure world on to the learner's mind (Jonassen, 1991). Since objectivists see the world as well-structured reality, personal experience is not considered when designing instruction. Conversely, constructivist believe that personal experience influences and helps structure a learner's knowledge and reality (Jonassen, 1991).

According to Reber (1993), sharing learning objectives with learners can bring to mind both positive and negative educational experiences. Sharing learning objectives with some learners may cause the learner to recall more negative educational experiences than positive experiences. The negative experiences could educe feelings and motivation that hinder learning. Because of these experiences for some learners and in some contexts, using implicit, or not sharing the learning objectives may be more beneficial to the students than sharing the learning objectives.

The empirical study conducted by Berry and Broadbent (1988) is a foundational study in implicit learning research (Seger, 1994). Berry and Broadbent (1988) used between- and within-subject factors to compare the effects of implicit and explicit instructions. They used a 2 X 2 between-subject factor design. One of the between-subject factors was the complexity of the multivariate relationships: simple or complex. Simple and complex referred to the relationship between the computer character's response and the participant's response. The other between-subject factor was the group: experimental or control. These groups were defined by the type of instructions they were given. The experimental group received three different types of instruction — implicit, explicit search, and explicit verbal, whereas, the control group only received implicit instructions.

The within-subject factor was three sets of trials. During each sets of trials, the experimental group received a different type of instruction whereas the control group received the same type of instruction during each set of trials. The participants were randomly assigned to one of the four groups: simple control group, complex control group, simple experimental group, and complex experimental group.

Forty-eight participants between the ages of 18–48 participated in each of the three sets of trials. Each set of trials included a different type of instruction. The instructions described behavior that participants should perform. These instructions were synonymous to learning objectives because, by definition, learning objectives describe the behavior as well as the conditions and a standard under which a behavior will be performed after instruction (Dick, Carey, & Carey, 2005)

During the first set of trials, participants in all four groups received implicit instructions. The instructions informed participants of their goal but did not mention the relationship among variables in the task, for example, “Shift the person’s [computer character] to the ‘very friendly’ level and maintain it at that level” (p. 6).

During the second set of trials, the two experimental groups received explicit search instructions that informed participants that there were relationships among variables in the task, for example, “You do realize that Ellis’s [the computer character] responses are related to your own – try to crack the pattern” (p. 6). The two control groups received implicit instructions.

During the third set of trials, the two experimental groups received explicit verbal directions that defined the relationship among variables, for example, “Ellis’s responses on any one trial depended only on their [participants’] immediately preceding behavior” (p. 6). The two control groups received implicit instructions again.

Each participant’s goal was to shift the computer character’s behavior from *polite* to *very friendly* and keep it at that level. During each set of trials, participants typed in one of 12 levels of behavior ranging from *very rude* to *loving*. After each participant’s response, the computer character responded with one of the 12 levels.

A student’s performance depended upon both the condition and the complexity of the multivariate system. Performance was measured by how many tries it took a participant to reach the goal and how many times a participant could sustain the goal.

They reported that implicit instructions had a more positive impact on the participants' game performance in the non-salient experimental group than the explicit search instructions; participants in the non-salient groups performed the task in a complex multivariate system. However, implicit instructions did not have a more positive impact on performance than explicit verbal direction. Implicit instructions also did not have a more positive impact on participants' performance in the salient groups; participants in the salient groups performed the task in a simple multivariate environment. This research shows that implicit instructions can have a positive impact on performance in complex multivariate systems. Authentic science environments are complex multivariate systems. Therefore, implicit instructions may also have a positive impact on performance on science tasks.

Explicit search instructions hindered participants in the non-salient experimental group but helped participants in the salient experimental group; the non-salient experimental group scored significantly lower than the non-salient control group and lower than both the salient control and salient experimental group. Explicit search instructions had a negative impact on participants' performance in a complex multivariate environment and had a positive impact on participants' performance in the simple multivariate system.

Explicit verbal directions had a more positive impact on performance than both explicit search instructions and implicit instructions. This was true for the salient control and experimental groups as well as for the non-salient control and experimental groups. Overall, explicit verbal directions defining the relationship among variables had a positive impact on performance in both simple and complex multivariate systems. However, simple multivariate systems and explicit verbal directions do not reflect authentic science environments. Thus, experience in a simple multivariate system and explicit verbal directions may not transfer to students' experiences in authentic science environments.

Based on Berry and Broadbent's (1988) results with implicit instructions in complex multivariate systems, implicit learning objectives may also prove beneficial in complex multivariate systems like authentic science environments. The effectiveness and appropriateness of explicit learning objectives may depend on the type of system. Rather, the appropriateness may depend on learner and context analysis. In complex multivariate systems, implicit learning objectives are a viable option.

Educational Games

Some argue that all too often, educational games are neither engaging nor educational (Papert, 1998). While well-designed entertainment computer games facilitate flow (Chen, 2004), educational games are purposely designed to teach. Others argue that explicit learning objectives, often included in educational games, are required for and lead to effective instruction (e.g., Morrison, Ross, & Kemp, 2004; Smith & Ragan, 2005). However, explicit learning objectives in educational games may not be engaging or effective with all students, specifically with struggling or unmotivated students who enjoy computer games. The negative experiences in academic settings of unmotivated or struggling learners impact the development of selective attention, the processes and expectations related to the flow state, and the development of self-efficacy and often cause more negative experiences. However, Berry and Broadbent's (1988) results on the comparative effects of implicit and explicit instructions on performance hint that implicit learning objectives may be able to stop this cyclical occurrence of negative experiences.

As previously stated, selective involuntary attention is influenced by repeated experience. As a result of recurring negative experiences, struggling or unmotivated students may associate explicit learning objectives with negative experiences: stress, boredom, and/or failure. Consequently, in order to avoid a negative experience, students may learn to automatically selectively attend to goals, events, or items not related to the explicit learning objectives. Thus, explicit learning objectives in games may induce stress, suppress motivation, and lead to avoidance, which impact the effectiveness of the game. For example, if a student feels foolish during science class, he or she may focus on entertaining the class rather than on achieving the learning objectives. Through repeated practice, the struggling student may learn to selectively avoid rather than attend to science. Anything related to science may cause avoidance. This lack of attention will impede performance.

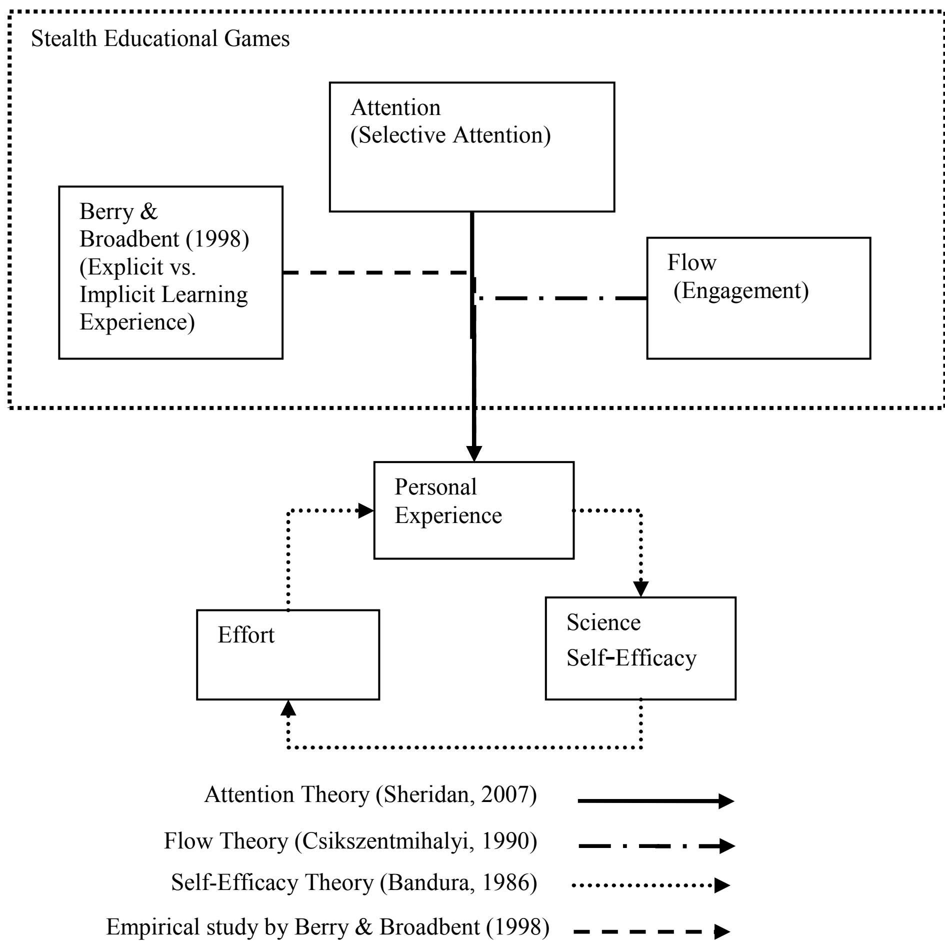
In computer games, the situational attributes that facilitate flow are defined by game elements such as storyline and character development. Since educational game developers do not focus their resources on providing the flow state, adolescents' standards and expectations for game elements may be different from or in direct opposition to what is usually provided in educational games. Educational games that superficially mimic the environment of entertainment games may not facilitate the flow state adolescents are expecting. The flow state leads to sustained focused attention that facilitates effort and performance. Without this flow state, struggling or unmotivated students may not put forth the level of effort that is necessary to learn. Not meeting these expectations leads to educational games that are not engaging to adolescents (Van Eck, 2006).

When discussing self-efficacy, domain and context are characterized by attributes of the environment and the activity. For struggling or unmotivated students, the attributes of the educational games or activities may trigger low self-efficacy, thereby strongly impacting effort and thus performance. One way to avoid triggering low self-efficacy is to put the person in an environment that triggers high self-efficacy, such as with video games. If the goal of the game is to improve low self-efficacy in a specific domain or context, the environment must subtly contain attributes that are related to that domain or context. The challenge is to subtly include those attributes without triggering low self-efficacy. In essence, the true purpose of the activity, improving low self-efficacy, is hidden from the person by the attributes of the environment. Stealth educational games fulfill this criterion.

Discussion

Given that educational games have not had the anticipated positive impact, and given that the Net Generation has a significant amount of experience with computer games, it is time for a new direction in educational games. Using the theoretical framework developed in this article, stealth educational games are proposed as that new direction (see Figure 3). Stealth educational games may be able to build the science self-efficacy of unmotivated or academically struggling learners. Educational game developers who want to help unmotivated or struggling learners should develop games that include the four attributes of stealth educational games.

Figure 3. A model for game design integrating attention theory, flow theory, self-efficacy theory, and an empirical study by Berry and Broadbent (1988).



Stealth educational games focus on entertaining the player in order to take advantage of the automatic attention processes that develop when playing entertaining games. These automatic attention processes are associated with specific situational attributes. Stealth educational games include similar situational attributes; these attributes are defined by elements in the computer game (e.g., narrative story, interactivity). The ability to automatically engage unmotivated or struggling students is especially important since these students may often choose or prefer to avoid anything related to education.

Additionally, as discussed previously, according to flow theory, situational attributes also define the environment that leads to a flow state, and flow is a desirable state that humans deliberately pursue. When in the flow state, learners report a high degree of concentration and self-confidence. This high degree of concentration and self-confidence has a positive impact on the player's personal experience (see Figure 3). When adolescents pursue the flow state, they often choose to play computer games. As a result of primarily focusing on entertaining the player, stealth educational games produce a flow state that is similar to the flow state adolescents experience when playing entertaining computer games. Consequently, they also produce a positive personal experience. According to self-efficacy theory, personal experience is a dominant source of self-efficacy (Bandura, 1986).

Stealth educational games also require players to apply complex rules in a multivariate system. Complex multivariate systems reflect authentic science environments and also promote practice variability. Similarity between environments and practice variability facilitates transference of self-efficacy across environments (Cervone, 2000). Practice variability implies that different choices during an experience can potentially cause different results. Practice variability in a complex multivariate system (i.e., stealth educational games) is facilitated by multiple variables and multiple relationships between variables. Self-efficacy developed through stealth educational games is expected to generalize to similar environments. Since the complex multivariate systems that are found in stealth educational games reflect the environment in which scientists practice science, through repeated practice, self-efficacy developed in stealth educational games is expected to transfer to science settings that reflect authentic science environments.

Stealth educational games should not inform players of the learning objectives in accordance with Berry and Broadbent's (1988) findings (see Figure 3). Implicit instructions rather than explicit instructions have a more positive impact on performance (personal experience) in complex multivariate systems such as stealth educational games. High performance in games can lead to positive personal experiences, thereby having a direct positive impact on self-efficacy.

Stealth educational games seamlessly integrate tasks that support the learning objectives in game play. Justification for this attribute is supported by concepts in flow theory. In order to sustain the flow state of learners who struggle or are unmotivated, learning tasks are seamlessly integrated into the game play. Seamless integration of the learning tasks will increase the likelihood that the games are engaging to unmotivated and/or struggling students. Unmotivated or struggling students may associate education with negative experiences.

People's natural tendency is to avoid negative experiences. During repeated negative experience in an educational or academic environment, unmotivated or struggling learners may learn to automatically attend to situational attributes that are not related to the lesson. This avoidance negatively impacts a student's effort in the lesson, which leads to a negative personal experience. Because of the circular relationship between self-efficacy, personal experience, and effort, students who are unmotivated or struggling academically may reinforce their low self-efficacy when they give little effort during a lesson. One way to avoid reinforcing low self-efficacy is to provide positive personal experiences, such as those provided by stealth educational games.

Conclusions

Based on the theoretical framework presented in this paper, to increase science self-efficacy of struggling or unmotivated learners the researchers recommends that:

- In informal learning environments that include both academics (e.g., tutoring) and fun (e.g., games), stealth educational games can be used to increase students' science self-efficacy.
- In formal learning environments, students must perceive the game as fun and not as a part of the lesson.
- In order for the science self-efficacy to transfer from the game, the environment in the science classroom should mimic authentic science.

Although stealth educational games' primary focus is entertaining the player, they also include implicit learning objectives. Counter to instructional design principles, implicit learning research suggests that explicit learning objectives can also negatively impact performance. Based on the arguments in this paper, the appropriateness of sharing learning objectives may not be clear cut. Rather, the appropriateness may depend on learner and context analysis. Using stealth educational games provides new avenues for helping unmotivated and/or struggling students.

CHAPTER IV

UNDER THE RADAR: THE EFFECTS OF STEALTH EDUCATIONAL GAMES ON INVESTIGATIVE SELF-EFFICACY

Preface

Minorities are underrepresented in the college-educated science workforce. The decision to pursue a science career is influenced by a person's investigative self-efficacy. This study examines the effects of entertainment and stealth educational computer games as well as stated and unstated learning objectives in those games on minority students' investigative self-efficacy. This quasi-experimental study was conducted in the after-school programs of three public elementary schools with 47 fourth- and fifth-graders. Data was collected for performance, degree of flow, and investigative self-efficacy. The results suggest that neither the type of game nor stated or unstated learning objectives has a positive effect on growth in investigative self-efficacy. However, the entertainment and stealth educational game had different effects on growth in performance, and when playing a stealth educational game unstated learning objectives had a greater positive affect on growth in performance and degree of flow than stated learning objectives had on growth in performance and degree of flow. The findings inform game designers and after-school program coordinators. When designing stealth educational games, designers should include a story and consider the amount of time available and required to achieve the learning outcomes. When selecting computer games for after-school programs, coordinators should consider the purpose of the activity as well as the time available for playing.

Introduction

This study examines the effects of a stealth educational game on minority adolescents' investigative self-efficacy. Investigative self-efficacy refers to a person's confidence in his or her ability to explore, understand, and predict or control events (Holland, 1996). These tasks are critical components of practicing science. Although, this study does not examine the effect of stealth educational games on career choices in science, it does pursue a deeper understanding of how to build investigative self-efficacy in minority students. Investigative self-efficacy (ISE) has been shown to be directly related to decisions regarding the pursuit of science careers (Gwilliam & Betz, 2001). Due to the clear relationship between investigative self-efficacy and decisions to pursue a career in science, this study focuses on computer games' effects on investigative self-efficacy.

Sustaining a high-quality science workforce as well as improving the quality of this workforce is imperative because science careers play an essential part in maintaining the United States' national security and economic success (Hart & Rudman, 1999). A high-quality science workforce generates innovative as well as creative ideas and practices, and innovation and creativity are promoted by diversity (Bassett-Jones, 2005). Unfortunately, the homogeneity of the current science workforce suggests a lack of diversity in thoughts and procedures. Underrepresented minorities (i.e., African-Americans, Hispanics, and Alaska Natives/American Indians; National Science Foundation [NSF], 2002) comprise 24% of the U.S. population and only 10% of the college-educated science and engineering workforce (National Science Board, 2010).

While adult minorities are underrepresented in the science workforce, adolescent minorities are adequately represented as players of video games. The popularity of computer games among minority adolescents make games a viable option for impacting adolescents' investigative self-efficacy. On a 2008 survey, 96% of Black parents, 89% of White parents, and 86% of Hispanic parents indicated that their teens (ages 12–17) played video games (Lenhart et al., 2008). The demographics of the parents (68% White Non-Hispanic; 11.6% Black Non-Hispanic; 14.4% Hispanic; 6% Other Non-Hispanic) reflected the demographics of the U.S. (Lenhart et al., 2008, p. 58). On the same survey, according to teens' self-report, 73% percent of these teens played computer games (Lenhart et al., 2008). Given the statistics, minorities' familiarity with and fondness for computer games may provide an avenue to impact their investigative self-efficacy and, thus, impact their decisions as adults to pursue science careers.

Several studies have investigated the effects of educational games on learning outcomes. These studies have reported inconsistent results (Van Eck, 2006). Some argue that these inconsistent results can be attributed to game design (Gee, 2003; Prensky, 2005). They argue that due to their design, sometimes educational games are neither entertaining nor educational (Papert, 1998). Video games have a lot to teach educators about learning (Gee, 2003). One of the 36 learning principles Gee (2003) extracted from video games suggests that a "learning environment should facilitate active and critical learning" (Gee, 2003, p. 207). However, game designers must be careful when designing explicitly educational games. Students may respond differently to games that put learning at the forefront. By integrating three theories and an empirical study, this researcher compiled four attributes that define a new direction for educational games, termed stealth educational games.

The four attributes that define a stealth educational game are not new. Stealth educational games are complex games that:

- do not inform players of the learning objectives,
- hide tasks that support the learning objectives in game play,
- focus on entertaining the player, and
- require players to apply complex rules in multivariate systems.

The integration of these attributes creates a new construct.

Stealth educational games are different from other educational games and entertainment games. They are different from other educational games because of the aforementioned four attributes. Stealth educational games include implicit or unstated learning objectives because they do not inform players of the learning objectives. Conversely, other educational games most often use explicit or stated learning objectives. Another distinguishing attribute is the requirement of the application of complex rules in multivariate systems. Other educational games may include only drill-and-practice activities, but stealth educational games must include the application of complex rules.

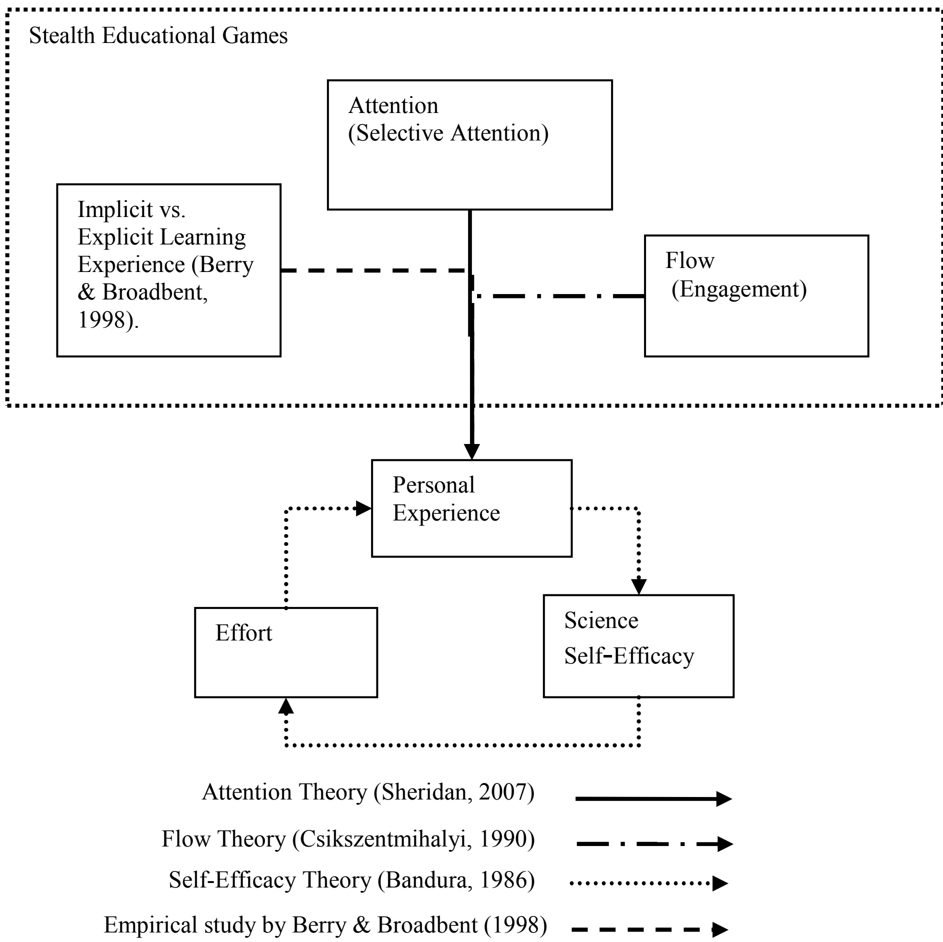
Stealth educational games are also different from entertainment games. Stealth educational games are designed to teach, whereas entertainment games are designed to amuse. Stealth educational games support active and critical learning while still entertaining the player. Specifically, stealth educational games mimic the environment in entertainment video games by focusing on entertainment and integrating learning in the game play. Hence, this study's purpose is to examine the effects of stealth educational computer games on minority adolescents' investigative self-efficacy.

Theoretical Framework

The integration of attention, self-efficacy, and flow theories as well as the results of an empirical study that investigates the comparative effects of explicit and implicit learning experiences provides a rationale for the ability of stealth educational games to increase investigative self-efficacy (see Figure 4).

Stealth educational games focus on entertaining the player in order to take advantage of the automatic attention processes that develop while playing entertaining games. The Net Generation chooses to spend a significant amount of time playing computer games. Through repeated practice, the voluntary attention they give in this environment progresses to involuntary attention (Matlin, 2005; Plude, Enns, & Brodeur, 1994; Schneider & Shiffrin, 1977). These automatic attention processes are associated with specific situational attributes. Stealth educational games include similar situational attributes, and these attributes are defined by elements in the computer game (e.g., narrative story, interactivity).

Figure 4. Integration of attention theory, flow theory, self-efficacy theory, and an empirical study by Berry and Broadbent (1988).



Additionally, situational attributes also define the environment that leads to a flow state, and flow is a desirable state that humans deliberately pursue (Csikszentmihalyi, 1990). When in the flow state, learners report a high degree of concentration and self-confidence. This high degree of concentration and self-confidence has a positive impact on the player's personal experience. When adolescents pursue the flow state, they often choose to play computer games. As a result of primarily focusing on entertaining the player, stealth educational games produce a flow state that is similar to the flow state adolescents experience when playing entertaining computer games. Consequently, they also produce a positive personal experience, which is a dominant source of self-efficacy (Bandura, 1986).

Stealth educational games also require players to apply complex rules in a multivariate system. Complex multivariate systems reflect authentic science environments. As mentioned previously, practicing science requires exploring, understanding, and predicting or controlling events. In the complex multivariate systems of stealth educational games, players have the opportunity to explore, understand, and predict or control events in a gaming environment. Therefore, experience in this environment should impact investigative self-efficacy.

Due to results reported by Berry and Broadbent (1988), stealth educational games employ implicit learning objectives, in other words the game does not inform players of the learning objectives. Berry and Broadbent (1988) compared the effects of explicit and implicit instructions on performance and found that implicit instructions rather than explicit instructions had a more positive impact on performance in complex multivariate systems like stealth educational games. The instructions described behavior that participants should perform in the game domain. Learning objectives, like these instructions, similarly describe the desired performance. Learning objectives also describe the conditions and the standard under which a behavior will be performed. The performance that Berry and Broadbent (1988) reported happened as a result of implicit learning instructions. Thus, implicit instructions can lead to positive personal experiences (see Figure 4), thereby having a direct positive impact on self-efficacy.

Stealth educational games seamlessly integrate tasks that support learning objectives in game play. Justification for this attribute of stealth educational games is supported by concepts in flow and attention theory which suggests that seamless integration of the learning tasks effects personal experience (see Figure 4). More specifically, it may increase the likelihood that a game is engaging and that a game sustains the flow state.

The combination of the aforementioned four attributes in a stealth educational game should build investigative self-efficacy. If a person gains investigative self-efficacy from gaming, that investigative self-efficacy may not necessarily transfer to scientific activity. Two issues are at play here: context and domain. Self-efficacy gained in the context of a game may not transfer to self-efficacy gained in the context of school or the workplace. In addition, the domain of self-efficacy gained from a game may not transfer to investigative self-efficacy. This may be explained by the nature of a stealth educational game. The dissimilarities between the context of the stealth educational game and other contexts may make it difficult for participants to transfer the self-efficacy to other contexts like the classroom or the workforce. Similarly, the implicit learning objectives in stealth educational games may make it hard for participants to transfer any self-efficacy they gain in the game to investigative self-efficacy. However, a review of the literature provides evidence that computer games can affect a specific self-efficacy domain.

Literature Review

A narrative synthesis of six studies suggests that computer games have the potential to impact self-efficacy. The six studies were identified in a systematic review of the literature. The six studies investigated the effect of computer games on self-efficacy. The detailed procedures for identifying these six articles can be found in Debose Columbus and Cifuentes (2010). The similarities across the six studies limits the generalizability of their findings while the variability makes it difficult to pinpoint which computer game elements affect self-efficacy.

Sample

The samples across these six studies were fairly homogenous. There were a total of 1,202 participants with sample size ranges between 59 and 371. The majority of the participants were undergraduate or college-age students. Three of the six studies included only undergraduate students (Behm-Morawitz & Mastro, 2009; Peng, 2008, 2009), two studies included both adolescents and college-age students (Kato, Cole, Bradlyn, & Pollock, 2008; Thomas, Cahill, & Santilli, 1997), and one included only adolescents (Brown et al., 1997). The two studies that included adolescents did not perform a comparative analysis to investigate the differences between adolescents and college-aged students. As a result, the results cannot be generalized to participants of other ages.

For the most part, the six studies were conducted at organizations connected to post-secondary education institutions (i.e., academic medical centers). Participants from four of the six studies were each a part of one organization (e.g., a university, an academic medical center; Behm-Morawitz & Mastro, 2009; Brown et al., 1997; Peng, 2008, 2009). Participants in the other two studies were from multiple organizations. Participants in the study conducted by Kato et al. (2008) represented 27 academic medical centers in the United States, six academic medical centers in Canada, and one academic medical center in Australia. The resources and values found in organizations connected to post-secondary institutions impact and limits generalizability of the results. The study by Thomas et al. (1997) was the only study that included organizations that were not affiliated with a post-secondary institution. Participants in the that study represented two group homes, two job corps sites, two rehabilitation centers, and two community-based organizations in New York.

Content Area

These six studies covered similar content areas. Five of the studies examined computer games' effects on health-related self-efficacy (Brown et al., 1997; Kato et al., 2008; Peng, 2008, 2009; Thomas et al., 1997) and one focused on general self-efficacy (Behm-Morawitz & Mastro, 2009). Three of the five studies that focused on health-related self-efficacy examined self-efficacy associated with preventing or managing diseases such as HIV, cancer, or diabetes (Brown et al., 1997; Kato et al., 2008; Thomas et al., 1997). The other two studies examined health-related self-efficacy associated with managing healthy eating (Peng, 2008, 2009).

Game Elements

Players' experiences in a computer game are defined by the elements included in the game; thus, the game elements are an important part of the narrative synthesis of these six studies. The computer games in the six reviewed studies highlighted a variety of elements (see Table 5). For instance, the common game element across all six studies was interactivity; interactivity implies that the player's experience depends on the player's choices. Also, five of the studies accentuated role-playing, which means that the player experiences the game as a character defined in the game (Brown et al., 1997; Peng, 2008, 2009; Thomas et al., 1997), and two of the studies focused on simulation, in which the game world mimics the real world (Peng, 2008, 2009). There were six elements that were unique to one of the six studies and three that were available in multiple studies. Variability in the game elements allows the results to speak to the general effect of computer games on self-efficacy. However, the variability does not reveal which elements have the greatest effect on self-efficacy.

Table 5

Game Elements Found in Six Systematically Identified Studies

	Brown, Lieberman, Gemeny, Fan, Wilson, & Pasta	**Thomas, Cahill, & Santilli**	**Peng**	**Kato, Cole, Bradlyn, & Pollock**	**Behm-Morawitz & Mastro**	**Peng**
Publication Year	1997	1997	2008	2008	2009	2009
Game	Packy & Marlon	Life Challenge	Mediated Enactive Experience	Re-mission	Tomb Raider	Rightway Café
Game Elements						
Interactive	X	X	X	X	X	X
Role-playing	X	X	X		X	X

Table 5 cont.

	Brown, Lieberman, Gemeny, Fan, Wilson, & Pasta	Thomas, Cahill, & Santilli	Peng	Kato, Cole, Bradlyn, & Pollock	Behm-Morawitz & Mastro	Peng
Simulation		X	X			X
Three dimensional				X		
Characters don’t die				X		
Character promiscuously dressed					X	
Narrative story						X
Competition						X
Challenge						X

Game Design

The researchers conducting the six studies either developed a game specifically for their study or used an existing game; each attributed their decisions to different theoretical frameworks. In four of the six studies, researchers developed a game specifically for the study (Brown et al., 1997; Kato et al., 2008; Peng, 2009; Thomas et al., 1997). The other two chose an existing game (Behm-Morawitz & Mastro, 2009; Peng, 2008).

Of the four studies for which a game was developed, three based decisions exclusively on theory, including situated learning, video game-based learning, and/or health behavior theories (Brown et al., 1997; Kato et al., 2008; Peng, 2008). In each of these three studies, theory guided the researcher's decisions regarding game elements. Researchers in the Brown et al. (1997) study purposely included game elements that supported fun, interactivity, role-playing, and learning; according to theories in cognitive psychology and education, these elements affect the development of self-concepts, provide social support, and support learning. Researchers in the Kato et al. (2008) study translated behavioral objectives into game elements and rules by following the principles of self-regulation in health, social cognitive theory, and learning theory. The researcher in the third study for which a game was developed, Peng (2009), decided to include role-playing because of situated learning theory and a narrative story because of the entertainment-education approach to behavior-attitude change. For the fourth study, researchers developed a game based on theory as well as focus groups (Thomas et al., 1997). Health education theory informed the game concept, whereas the responses of the focus groups guided the development of the storyline and graphics.

Of the two studies for which an existing game was chosen, researchers in one based it on a pilot study (Behm-Morawitz & Mastro, 2009), and the researcher in the other study based it on social cognitive theory and the health belief model (Peng, 2008). The researchers in the Behm-Morawitz and Mastro (2009) study used a pilot study to find two games that included specific game elements, or more specifically, that the games "effectively manipulated the sexualization of the female character" (p. 813). Peng (2008) chose an existing game that included specific game elements (e.g., role playing and fun) based on social cognitive theory and the health belief model.

The variability in the theoretical underpinnings of the six identified studies helps the results describe the general effect of computer games on self-efficacy. Nonetheless, in order to inform theory, the future research should systematically compare how specific elements of a theory, such as positive and negative feedback effect self-efficacy.

Using Cohen's formula, the researchers calculated small to moderate effect sizes for each of the six studies (.03–.59). The small to moderate effect sizes of these studies suggest that computer games can affect self-efficacy. Even a small effect size is significant because of the prevalence of computer games in society and the recognized effect of self-efficacy on a myriad of factors such as motivation, effort, and choices (Bandura, 1986; Lent, Brown, & Hackett, 1994).

These six studies had significant differences and similarities. For instance, the six studies were different in that each study based decisions on different theories and utilized different games. These differences made it difficult to draw definitive conclusions regarding computer games effect on self-efficacy. On the other hand, the studies were similar in that most focused on self-efficacy related to health and on undergraduate or college-age students who were linked to academic institutions. These similarities illustrated the restricted applicability of the current body of literature. Hence, the goal of this study was to address the limited content coverage, limited context, and limited audience.

The six aforementioned studies suggest that there is a gap in the field. The current studies were conducted with similar age groups, in similar settings, and on similar content. Because of the diversity of the gaming population, future research should be conducted in more diverse settings with diverse samples from that population. Because most of the studies examined self-efficacy related to health, future research should include self-efficacy related to other domains, such as careers. The six studies also explored the effects of a variety of game design elements. In order to inform design of games, the next iteration of research should systematically compare the effects of specific game elements.

Purpose of Study

This study addresses the limited content coverage and limited audience identified in the systematic literature review by focusing on how computer games affect investigative self-efficacy of minority pre-teens. Investigative self-efficacy impacts decisions to pursue science careers. Given the underrepresentation of minorities in the science workforce and the fact that this underrepresentation can impact national security and economic success, this study focuses particularly on how computer games affect investigative self-efficacy of minorities. This study focuses expressly on minority pre-teens for two reasons: 1) preparation for science careers can depend on educational course work and choices during middle school, high school, and/or college; and 2) the current body of literature focuses primarily on college-aged students.

This empirical study looks specifically at how stealth educational games affect investigative self-efficacy of minority pre-teens in after-school programs. Stealth educational games strive to facilitate flow and engagement by mimicking entertainment games and hiding the learning objectives. Stealth educational games should appeal to minority pre-teens and take advantage of their experience with computer games.

Conducting this study in after-school programs addresses two needs: 1) the context helps hide the educational nature of the stealth educational; and 2) in the current body of literature, most studies were limited to organizations connected to post-secondary institutions.

This quantitative study was conducted in the real-world setting of elementary after-school programs to discover how personal experience during a stealth educational game affects investigative self-efficacy. Personal experience is defined by player performance and the degree of flow (or engagement) while playing a game. Personal experience is expected to be impacted by the type of computer game (e.g., entertainment vs. stealth educational) as well as the stated and unstated learning objectives.

This study sought to answer two research questions about how the type of computer game as well as stated and unstated learning objectives affected investigative self-efficacy in pre-teens. According to the theoretical framework, whether a game's purpose is for entertainment or for education should affect personal experience of that game, which in turn affects self-efficacy. Personal experience is operationally defined as degree of flow and performance. For that reason, the first research question examines the effect of the type of game on growth in performance, degree of flow, and investigative self-efficacy (see Figure 5).

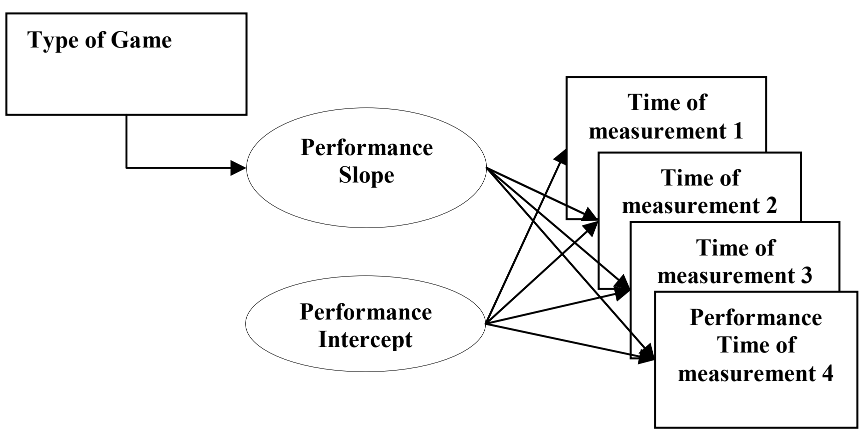
RQ1: Does playing an entertainment or stealth educational game effect growth in player performance (Perf), growth in the degree of flow (Flow), and growth in investigative self-efficacy (ISE)?

Hypothesis 1a: The entertainment game effect on growth in performance will not be different from the stealth educational game effect on growth in performance.

Hypothesis 1b: The entertainment game effect on growth in degree of flow will not be different from the stealth educational game effects on growth in degree of flow.

Hypothesis 1c: The entertainment game effect on growth in investigative self-efficacy will be less than the stealth educational game effect on growth in investigative self-efficacy.

Figure 5. Measurement model for performance for Research Question 1. A similar model was used for degree of flow and investigative self-efficacy.



The second research question emerged from the definition of stealth educational game. One attribute of stealth educational games is unstated learning objective. The second research question delves into how stated and unstated learning objective affects the player's personal experience and accordingly, investigative self-efficacy (see Figure 6). Personal experience is again operationally defined by degree of flow and performance.

RQ2: Do stated or unstated learning objectives while playing a stealth educational game effect growth in performance (Perf), degree of flow (Flow), and investigative self-efficacy (ISE)?

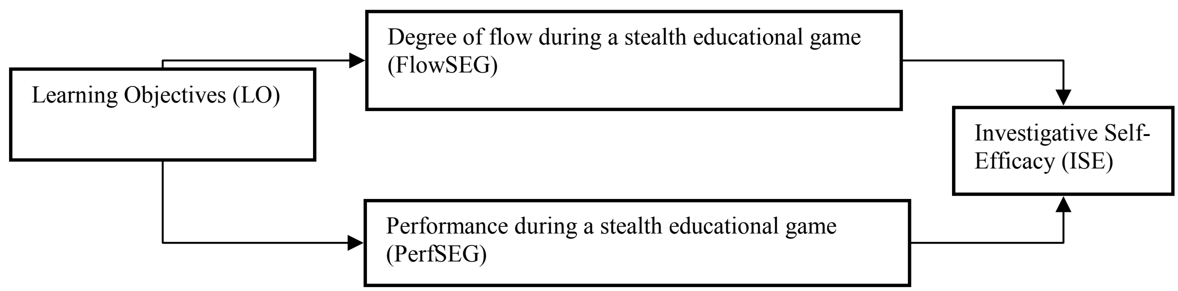
Hypothesis 2a: The unstated learning objectives effect on growth in performance will be greater than the stated learning objectives effect on growth in performance.

Hypothesis 2b: The unstated learning objectives effect on growth in degree of flow will be greater than the stated learning objectives effect on growth in degree of flow.

Hypothesis 2c: The unstated learning objectives effect on growth in investigative self-efficacy will be greater than the stated learning objectives effect on growth in investigative self-efficacy.

Hypothesis 2d: The effect of the stealth educational game on growth in investigative self-efficacy will be completely mediated by performance and degree of flow.

Figure 6. Path model depicting the relationships that were examined to answer Research Question 2.



Methodology

The researcher carried out the empirical study at three after-school programs in three public elementary schools in a metropolitan city in Texas. The same researcher designed the interventions for the study, implemented the interventions, and measured outcomes to increase the likelihood of systematic validity. Systematic validity refers to the validity of results and inferences based on those results. It is facilitated when the same person designs an intervention, implements the intervention, and measures the outcomes of the intervention (Hoadley, 2004).

Participants

A purposeful sampling of public elementary schools that offered after-school programs helped to ensure that the participants in the study included minorities that are currently underrepresented in the science workforce (see Table 6). Six schools were identified, but only three agreed to participate in the study. Approximately 90% of the students at the three schools were African-Americans or Hispanics. Furthermore, 70% of all students at the three schools were labeled *at-risk* using the Texas Education Agency definition (TEC §29.081, Compensatory and Accelerated Instruction).

Table 6

Percentage of Minorities in Each of the Three Schools

	Number of Students	**% of Minorities**	**n**
School 1	685	86.3	591
School 2	479	79.8	382
School 3	410	95.4	391
Total	1574	90	1365

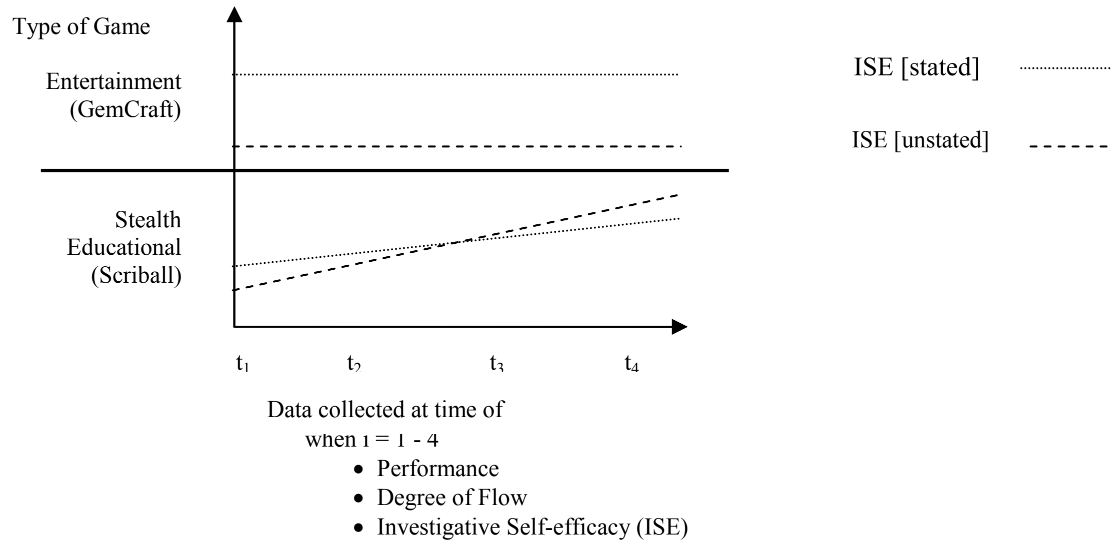
The study was advertised to school principals and coordinators of the after-school program at each of the six chosen schools via email, phone conversations, and face-to-face meetings, with the hope of conducting the study at four schools. Three schools agreed to participate. The after-school coordinator decided the dates and time that the program would be offered to the students. The study, which was titled "MySpace: MyGames, MyLikes & MyStrengths," was then advertised via flyers and announcements to students who participated in the after-school program. Potential participants were told that the goal of the study was to discover more about their likes and strengths so that the after-school program could design better activities.

Data was collected from only those students who returned parental consent forms. Sixty-two out of 120 fourth- and fifth-graders in the after-school programs returned parental consent forms. Fifteen of these 62 students were absent on three of the four days of the study. These 15 students were not included in the final sample of students. Consequently, the final sample of students included 47 students. The 78 students in the final sample included a high ratio of underrepresented minorities, according to the National Science Foundation (2002) definition. The 47 participants included 44 minority students (89%); of those 44, 30 were African-Americans (63%) and 14 were Hispanic (29%). Additionally, 26 participants were female (56%), whereas 21 were male (44%).

Design

This quantitative study used between-and within-subject factors to examine the effects of the type of computer game as well as stated and unstated learning objectives on growth in performance and degree of flow, and in turn, these two variables' effects on growth in investigative self-efficacy (see Figure 7). To examine these relationships, data was collected at four times of measurement (t_i) for three variables: performance, degree of flow, and investigative self-efficacy (ISE).

Figure 7. Design for between- and within-subject factors.



The 2 x 2 between-subject factors were the type of game (e.g., entertainment and stealth educational) and the learning objectives (e.g. stated and unstated). The type of game was defined based on the game designer's stated purpose of the game, whereas the learning objectives were defined based on the researcher's actions before and after learners play the game.

The stated and unstated learning objectives described the intervention. The stated learning objectives intervention meant that the researcher told participants the game's objectives and the learning objectives and discussed how the actions participants performed in the game were related to the learning objectives. The unstated learning objectives intervention meant that the researcher told participants the game's objectives but did not discuss learning objectives.

The two between-subject factors and their corresponding levels created four groups: 1) entertainment game with unstated learning objectives, 2) entertainment game with stated learning objectives, 3) stealth educational game with unstated learning objectives, and 4) stealth educational game with stated learning objective (see Table 7).

Table 7

Sample Size of Each of the Four Groups

Learning Objectives\Type of Game	**Entertainment**	**Stealth Educational**	**Total**
Unstated Learning Objectives	10	22	32
Stated Learning Objectives	7	8	15
Total	17	31	47

The within-subject factor was the time of measurement. The research questions focused on growth: "in models capturing growth or development over time, the within-subject factor is time of measurement" (Duncan, 1999, p. 33). On each of the four days, data was collected for each participant's performance, degree of flow, and investigative self-efficacy.

Six schools were recruited and were randomly assigned to one of the two levels of the learning objectives variable: 1) unstated learning objectives, or 2) stated learning objectives. Unfortunately, following random assignment, three of the six schools decided not to participate: one school assigned to the unstated learning objectives condition and two assigned to the stated learning objectives condition. Accordingly, of the three schools that participated, two experienced the unstated learning objectives condition and one experienced the stated learning objectives condition.

At each school, there were two groups of students. One group of students played the entertainment game, and the other group played the stealth educational game. All participants at a school experienced the same level of the learning objectives for the duration of the study. Thus, at one school, participants experienced the entertainment stated learning objectives intervention or the stealth educational game stated learning objectives intervention.

Games

Two games for the study were chosen using a systematic process. First, fourth- and fifth-graders played eight games across a 5-day period: three stealth educational games and five entertainment games. Based on the enjoyment levels of 17 fourth- and fifth-graders in a summer school program, the eight games were reduced to two stealth educational games and two entertainment games. At a later date and in a different school, from the four games, the two games to be used in the study were identified based on the capabilities of the school's computers to smoothly run the games under review.

Scriball was chosen as the stealth educational game based on the configuration of the computers in the school and because it adheres to the definition of stealth educational games. Scriball is a commercial, single-player game developed by Gaz Thomas. The game was developed to teach players how to draw different types (i.e. straight, curve, slanted) of lines using the computer. The goal of the game is for players to direct a ball to specific blue and red dots on the screen by bouncing the ball and drawing a line. The ball rolls along the line drawn by the player. If the line is flat, the ball will not roll. The player can draw only one line on the screen at a time but may redraw the line as many times as he or she wants. When the player draws the line, he or she must make sure that rolling along the line will not cause the ball to hit obstacles that will burst the ball. To bounce the ball, the player presses the space bar or clicks the mouse. There are 43 levels in the game, and each level contains different obstacles. Each time the player successfully completes a level, he or she advances to another level.

Scriball includes the four attributes that define stealth educational games. It has a hidden objective in that it teaches players how to draw lines without stating that as the purpose of the game. Second, it hides the supporting learning tasks in game play. In fact, players are told that the goal is to get a yellow ball from one point on the screen to a target spot. Third, from the learner's perspective, the game focuses on entertainment rather than on learning. Fourth, the objective is learned in a complex multivariate system. In order to accomplish this goal, the player must consider multiple variables, including location and types of obstacles (e.g., disappearing stars), the slope of the line, the speed of the ball, and the location of the target spot. In order to succeed, the player must apply complex rules and must actively explore, understand, and predict as well as control what happens to the ball. All of the skills required for the game are those that conceptually define investigative self-efficacy.

On the other hand, the entertainment game used in this study was a commercial game called GemCraft®, a single-player game developed by Armor Games. The goal of the game is for players to save the village by shooting monsters. The player places shooting gems or obstacles on various spots on a map. After the player places the gem, he or she watches the monsters as they travel a specified path toward a house in the village. If the monsters make it past the shooting gems without being destroyed, they will damage and/or destroy the house. If the monsters do not make it past the shooting gems or do not destroy the house, another map is made available to the player. The player may choose to replay the same map or play a new map. If the monsters do make it past the shooting gems and do destroy the house, the player does not receive access to a new map. The player may choose to replay the same map or play an old map. Each map contains a different amount and classes of monsters, and some monsters are harder to destroy than others. Players are awarded points based on how many monsters are destroyed.

GemCraft was chosen as the entertainment game because the game is not educational. The game does not include a learning objective; instead, the goal is simply to save the village. Since the game does not include a learning objective, learning tasks related to the objective are not hidden in game play. The game does include multiple variables, but success in the game does not require applying complex rules or exploration of these variables. Therefore, the game does not mirror authentic science environments and does not adhere to the definition of stealth educational games. In GemCraft, the player can succeed simply by placing shooting gems and watching what happens. The skills required for success in the game are psychomotor and do not involve application of complex rules, active exploration, or prediction, the skills associated with investigative self-efficacy.

Assessments

There were two exogenous variables and one endogenous variable in this study. Personal experience in games was evaluated based on participants' performance during the game, and degree of flow, and investigative self-efficacy were assessed after each game-playing session.

Performance in games. Performance in the stealth educational game, Scriball, was measured using the levels completed in the game (range 0–43), while performance in the entertainment game, GemCraft, was measured using the points scored in the game (range 0–infinity). For both games, higher levels and higher points reflected a better performance.

Degree of flow. Fourteen of the 19 Likert-scaled questions were related to degree of flow. The average of these 14 questions was used to assess the degree of flow while playing the entertainment or stealth educational games. The 14-question survey, called the Game Experience Questionnaire (GEQ), was developed by the Fun of Gaming (FUGA) Project. On each of the 14 questions, players indicated how they felt playing the game (i.e., "I felt extremely bored," where 0 = *not at all* and 4 = *extremely*). The questions addressed seven media enjoyment components: competency, sensory and imaginative immersion, tension, flow, challenge, negative effect, and positive effect. Internal consistency was established by Nacke and Lindley (2008) in 2005 (r = .68–.94).

Substantive validity was enhanced by removing, rewording, and adding questions based on data collected during focus groups with 23 people, ages 19-27, who played games at least once a month or played games at least once a week (Poels, de Kort, & IJsselstein, 2007; see Appendix A). Content validity for this study was established by revising the questions based on the expert opinion of 17 fourth- and fifth-graders.

Investigative self-efficacy. Five questions of the 19 Likert-scaled questions comprised the ISE Questionnaire. The ISE Questionnaire consisted of five Likert-scaled questions adapted from the Inventory of Children's Activity–Revised (ICA-R) Investigative subscale. The average of these five questions was used to assess investigative self-efficacy. Tracey and Ward (1998) reported an internal consistency for the ICA-R of .80 and 1-week test-retest reliability of .84 for the ICA-R Investigative subscale among middle-school students. Content validity was established by a university math education professor and two middle-school science teachers who reviewed the ISE Questionnaire and agreed that the instrument measured ISE. Three of the five questions on the ISE Questionnaire were the exact questions from the ICA-R Investigative subscale. The other two questions were modified to exclude the words *science* and *microscope*, which the researcher felt might give participants the impression that the game was related to science and, as a result, suggest an educational component of the study or game (see Appendix B).

Procedures

Data from three sources were used to examine the two research questions: participants' self-reports, the computer games, and the researcher's notes. Participants' self-reports on two surveys were used to assess degree of flow and investigative self-efficacy. The computer games were used to assess participants' performance during the games, whereas the researcher notes were used to discuss and explain the quantitative results.

Each of the three schools was assigned to an intervention. At each of the three schools, each day the researcher conducted the study for two sessions. Each student was assigned to a session before the study began by the after-school program coordinator, and each day students participated during their assigned session. The name for each of the sessions can be seen in Table 8.

Table 8

Name for Six Sessions Organized by School

	Game 1	**Game 2**
School 1	S1G1	S1G2
School 2	S2G1	S2G2
School 3	S3G1	S3G2

Each of the six sessions was assigned a type of game so that the entertainment and stealth educational games were played by students at each school (see Table 9). Once a game was assigned to a session, participants assigned to that session played that game for the duration of the study. Thus, participants at each school played the stealth educational game, Scriball, or the entertainment game, GemCraft, but they did not play both games.

Table 9

Session Assignments to Intervention and Game

Intervention\Game	Entertainment (GemCraft)	Stealth Educational (Scriball)
Unstated Learning Objectives	S1G1 and S3G2	S1G2 and S3G1
Stated Learning Objectives	S2G2	S2G1

Each session began with administrative tasks such as taking attendance, repeating instructions, reviewing the information sheet, collecting parental consent forms, and selecting computers. The researcher gave one of four instructions before participants played the game; the instructions given depended on the intervention and the game. For instance, participants in the unstated learning objectives intervention were told the game's goal but were not told that they would learn:

- Unstated GemCraft: "Your goal in GemCraft is to protect the villages from the monsters."
- Unstated Scriball: "Your goal in Scriball is to move the yellow ball to the green spot on the screen by drawing a line."

Conversely, participants in the stated learning objectives intervention were told the game goal and that they would learn. The goal was to get the students to believe that they were learning, so even though GemCraft is not an educational game, the students in the stated learning objectives intervention who played GemCraft were told that learning was a part of the game.

- Stated GemCraft: “Your goal in GemCraft is to protect the villages from the monsters. By playing this game, you will *learn* how to explore, understand, predict, and control what happens in the village.”
- Stated Scriball: “Your goal in Scriball is to move the yellow ball to the green spot on the screen by drawing a line. By playing this game, you will *learn* how to explore, understand, predict, and control what happens to the ball.”

After administration tasks were completed, participants were told to start the game and that they would play for 25 minutes. After 25 minutes, participants were instructed to stop playing the game. In school 1, participants were instructed to leave the computers and return to their seats. In school 2 and school 3, participants were instructed to take their hands off the mouse and face the researcher.

At this point during the session and before completing the survey, participants in the stated learning objectives intervention were told that they would participate in a discussion with the researcher. The purpose of the discussion was to stress the stated learning objectives. During the discussion, the participants answered the following five questions:

1. What was hard today? What was easy?
2. As you explored the solution to <what was hard or easy today?>, what did you figure out?

3. As you began understanding how to handle <what was hard or easy today?>, what did you learn?
4. When you predicted what would happen as a result of your decisions, what did you consider?
5. As you learned to control the lines in Scriball (or gems in GemCraft), what was easier?

Participants in the unstated learning objectives intervention did not participate in a discussion.

All groups were given the same instructions for completing the survey to establish degree of flow and ISE. They were told that it was important that they be honest and that they complete the entire survey. They were also told that their feedback was valuable to the design of future after-school activities. As participants completed the survey, the researcher read each question to the students and answered questions about terms and/or instructions.

After-school activities at school 1 lasted 50 minutes. After completing the survey, each group of participants at school 1 was transported to its next after-school activity by an after-school employee. During the transition, the researcher collected each survey, visited each computer, documented student performance, and got the game ready for the next group of students.

All after-school activities at schools 2 and 3 lasted for 90 minutes, including the activity designed for this study. Thus, after playing the game and completing the survey, students still had time left. To fill this time and to maintain order, participants were allowed to play other computer games approved by the school district after finishing the study activity. As a result, the researcher was not able to visit each computer and document student performance. Thus, before students began playing other approved games, they were asked to document their performance on their survey and turn it in.

After the four days of data collection, the researcher facilitated a debriefing discussion with the participants. The discussion began with participants sharing their ideas about the purpose of the study. At the end of the discussion, the researcher revealed the true purpose of the study and told participants how to access the games via the Internet.

Analysis and Results

For this study, the researcher employed a latent growth model to test the proposed hypotheses. Analysis was conducted using MPlus®. Data analysis was completed in three steps: (1) data preparation; (2) data validation, reliability, and model fit; and (3) hypothesis testing.

Data Preparation

The first step in data preparation was a search for missing data patterns and outliers using MPlus. The search of the data collected from the 62 participants who returned parental consent forms revealed 27 different patterns. Next, any participant who participated on only one day was removed from the sample. This reduced the missing data patterns to 24 in the structural models and 12 in the measurement models. The final sample size was 47.

A search for outliers in each of the three variables at each of the four times of measurement revealed 13 participants with outlier scores for the degree of flow, 0 participants with outlier scores for performance, and 2 participants with outlier scores for investigative self-efficacy scores. To handle the outliers and test for normality, the researcher examined the data for skewness and kurtosis. A closer examination revealed that values for skewness were within the recommended +/-3 range, but values for kurtosis were not within the recommended +/-3 range for two variables at two different times of measurement: 1) degree of flow at time of measurement 1; and 2) investigative self-efficacy at time of measurement 2. Because removing participants with outlier scores for these variables did not change the distribution and MPlus® can handle non-normal data, participants were not removed from the sample.

The search for missing data patterns and outliers was followed by an examination of descriptives, a test for homogeneity of variance across groups at each of the four times of measurements, and a time invariance across the four times of measurements. The means and standard errors for each of the three variables were calculated for each of the four days of data collection. These means were calculated across the types of games and across stated and unstated learning objectives (see Table 10).

Performance in the entertainment game and stealth educational game were in different units; performance on the entertainment game ranged from 0–infinity, and performance in the stealth educational game ranged from 0–43. In order to complete the statistical analysis, the performance scores needed to be in the same units. Consequently, for each game, the following calculations were used to standardize the performance scores:

1. The average and standard deviations were calculated for performance scores at the four times of measurement. For instance, the 'mean (standard deviation)' for

performance in the stealth educational game at time of measurement 1 was 9.5 (1.88) and at time of measurement 2 was 15.66 (3.4).

2. A standard ratio (SR) at each time point was computed by dividing the standard deviation at each time point by the standard deviation at time point 1. For stealth educational game, the SR for time point 2 was 3.44/1.88 = 1.83. The standard deviation at time point 2 was 1.83 times the standard deviation at time point 1.
3. Within each group, the mean for time of measurement 1 was subtracted from each participant in a group. For participant 1, this difference was 18 – 9.5= 8.5.
4. This difference was divided by the standard ratio. For participant 1 in the stealth educational game, this value is 8.5/1.83 = 4.64. The difference was 4.64 units times the standard ratio.

This means that participant one's performance score at time point 2 was the mean of time point 1 (e.g. 9.5) plus 4.64 standard units, where one standard unit equals 1.83 time the standard deviation of time point 1 (e.g. 1.88). As a result of applying the above process to performance scores on both games, each participant's transformed scores represents a multiplier of the standard deviation at time point 1.

Table 10

Means (SD) of Scores across Four Days of Data Collection Organized by Type of Game and Learning Objectives

Type of Game		**Entertainment**			**Stealth Educational Game**		
Learning Objective (Sample Size)		Stated (N=7)	Unstated (N=10)	Overall (N=17)	Stated (N=8)	Unstated (N=22)	Overall (N=30)
Performance	1		.00 (.42)	.00 (.42)	.46 (.47)	-.36 (.21)	.00 (.54)
	2	.09 (0.38)	-.20 (.59)	-.13 (.53)	.25 (.63)	.45 (.47)	.37 (.54)
	3	-.64 (0)	.04 (.61)	-.06 (.61)	.49 (.49)	.63 (.57)	.57 (.53)
	4	-.38 (.37)	.02 (.42)	-.09 (.42)	.60 (.25)	.62 (.55)	.61 (.47)
Degree of Flow (Range: 0-4)	1		2.64 (.98)	2.64 (.98)	2.78 (1.19)	2.72 (.44)	2.74 (0.72)
	2	1.98 (.86)	2.87 (.69)	2.51 (.86)	3.04 (1.58)	2.43 (.80)	2.63 (1.12)
	3	1.77 (.68)	2.76 (.31)	2.26 (.72)	2.66 (1.06)	2.47 (.69)	2.52 (0.79)
	4	2.23 (.96)	2.66 (.39)	2.45 (.73)	3.05 (.57)	2.53 (.60)	2.67 (0.63)

Table 10 cont.

Type of Game		Entertainment			Stealth Educational Game		
Learning Objective (Sample Size)		Stated (N=7)	Unstated (N=10)	Learning Objective (Sample Size)	Stated (N=7)	Unstated (N=10)	Learning Objective (Sample Size)
Investigative							
Self-efficacy			3.53		4.33	3.96	4.07
(Range: 1-5)	1		(.88)	3.53 (.88)	(.75)	(.50)	(0.59)
	2	4.12	3.87	3.99 (.74)	4.73	4.04	4.27
		(.73)	(.78)		(.41)	(.92)	(0.85)
	3	3.97	3.87	3.91 (.68)	4.75	3.99	4.20
		(.69)	(.74)		(.44)	(.78)	(0.77)
	4	4.08	4.08	4.08 (.76)	4.57	4.22	4.31
		(.79)	(.81)		(.57)	(.70)	(0.67)

After examining the descriptive statistics, homogeneity of variance was examined for performance, degree of flow, and investigative self-efficacy on each day across the entertainment and stealth educational game groups as well as across the stealth educational game stated-learning-objective and stealth educational game unstated-learning-objective groups (see Table 11). Performance exhibited homogeneity of variance across the entertainment and stealth educational game but not across the stealth educational game stated learning objectives and stealth educational game unstated learning objectives. The degree of flow exhibited homogeneity of variance across the entertainment and stealth educational game but not across the stealth educational game stated learning objectives and stealth educational game unstated learning objectives. Investigative self-efficacy exhibited homogeneity of variance across

Table 11

Test of Homogeneity of Variance: Levene's Test Statistic (sig.)

		RQ1: Entertainment Game vs. Stealth Educational Game	**RQ2: Stealth Educational Game:** Stated vs. Unstated
Performance			
	1	2.00 (.17)	7.03 (.02)*
	2	.02 (.90)	1.98 (.17)
	3	.61 (.44)	.11 (.75)
	4	.11 (.75)	3.17 (.09)*
Degree of Flow			
	1	.98 (.33)	3.42 (.08)*
	2	.01 (.94)	2.06 (.17)
	3	.00 (.98)	1.04 (.32)
	4	.00 (.95)	.09 (.77)
Investigative Self-efficacy			
	1	1.50 (.23)	1.70 (.20)
	2	.48 (.50)	.60 (.45)
	3	.14 (.71)	2.90 (.10)
	4	.51 (.48)	.72 (.40)

* alpha < .10

the entertainment and stealth educational game as well as across the stealth educational game stated learning objectives and stealth educational game unstated learning objectives.

Addressing lack of homogeneity of variance required two steps. The first step was to analyze time invariance for performance, degree of flow, and investigative self-efficacy. The second step depended on the results of the time invariance analysis. If the construct exhibited time invariance, the construct values were adjusted based on the standard deviation at time of measurement 1. If the construct did not exhibit time invariance, the variances were examined for systematic increase or decrease. If the variances did not exhibit systematic increase or decrease, the construct values were adjusted based on standard deviation at time of measurement 1.

Time invariance provides evidence that the same construct is being assessed at each time of measurement, whereas variance suggests that the structure of the construct is changing each time of measurement (Widaman, Ferrer, & Conger, 2010). Time invariance for performance, degree of flow, and investigative self-efficacy was explored using the chi-squared differences of full and restricted models. Performance exhibited time invariance for Research Question 1 (chi-squared = 1.92, df = 3, cv = 7.84) but not for Research Question 2 (chi-squared = 8.76, df = 2, cv = 5.99). Degree of flow did not exhibit time invariance for Research Question 1 (chi-squared = 15.12, df = 3, cv = 7.84) or Research Question 2 (chi-squared = 14.51, df = 3, cv = 7.84). Investigative self-efficacy exhibited time invariance for Research Question 1 (chi-squared = 6.50, df = 3, cv = 7.84) and Research Question 2 (chi-squared = 4.62, df = 3, cv = 7.84).

The performance variances did not reflect systematic increase or decrease. Hence, the researcher surmised that the variance across times of measurement may be explained by contextual and environmental variables (i.e., noise in classroom, disciplinary actions taken before class) and kept the adjusted construct values based on the standard deviation of time of measurement 1.

Data collected from the survey used to measure degree of flow exhibited both reliability and validity. The survey was also validated by a number of other researchers. In addition, the variances did not reflect systematic increase or decrease. Hence, the researcher surmised that the variance across times of measurement may be explained by contextual and environmental variables (i.e., noise in classroom, disciplinary actions taken before class) and proceeded with adjusting the construct values based on the standard deviation of time of measurement 1.

Validation of Data

Messick (1989) described validity of assessments in terms of four facets: test interpretation, test use, evidential basis, and consequential basis. Construct validity of the data collected during this study speaks to three of these facets: test interpretation, test use, and evidential basis. Construct validity was established using content validity, convergent validity, and discriminant validity. In addition to Messick's (1989) description of validity, Hoadley's (2004) recommendations for establishing systematic validity were also carried out.

Content validity. Messick (1989) contended that expert judgment is one component of content validity. Because the survey used in this study was adapted from two previously validated assessments, a professor, former public school elementary teacher, and 17 fourth- and fifth-graders reviewed the modifications to facilitate content validity.

Convergent validity. Convergent validity seeks to establish that a similar construct is being measured by each item on the assessment. This was explored using confirmatory factory analysis of 19 items on the two surveys. The 19 questions loaded on four factors: degree of flow (positive; DF(+)), degree of flow (negative; DF(-)), investigative self-efficacy factor 1 (ISE F1), and investigative self-efficacy factor 2 (ISE F2; see Table 12). The 19 questions were labeled ISE Q1 thru ISE Q5 for the investigative self-efficacy items and DF Q1 thru DF Q14 for the degree-of-flow items.

When a variable loads on multiple factors, the variable can be attributed to a factor based on its most prominent loadings (Tinsley & Tinsley, 1987) and further supported by theory. Using this recommendation, the results indicate that four items (ISE Q2–Q4) related to investigative self-efficacy loaded distinctly on two factors (ISE F1 and ISE F2), and one item (ISE Q1) did not clearly load on any factor. The 14 items related to degree of flow during the game loaded on the other two factors: DF (+) and DF (-).

The two factors for investigative self-efficacy can be explained by the nature of the questions. ISE Q2 loaded on factor 2, ISE F2, whereas ISE Q3, ISE Q4, and ISE Q5 loaded on factor 1, ISE F1. ISE Q2 was different from ISE Q3, ISE Q4, and ISE Q5 in that it asked students to indicate how good they were at taking things apart. Participants asked for examples of these kinds of activities, and the researcher typically gave examples like taking apart a TV or a toy. Taking things apart was not as common in their lives as the other three activities mentioned in ISE Q3, ISE Q4, and ISE Q5 (i.e., searching the Internet).

The unclear loading of ISE Q1 may also be explained by the nature of the question. ISE Q1 referred to an abstract concept (e.g., understanding how things work together), whereas the other four ISE questions referred to concrete actions (e.g., searching the Internet). As a result of the conceptual vagueness of the term *understand*, participants may have interpreted the question differently. The score for investigative self-efficacy was computed by averaging ISE Q1 thru ISE Q5. ISE Q1 was included in ISE because its loadings were higher for the investigative self-efficacy factors than the degree-of-flow factors and also because of the theoretical relationship between ISE Q1 and ISE Q2–ISE Q4.

The two factors for degree of flow can also be explained by the nature of the questions. The items that loaded on DF (+) were feelings that could add to the degree of flow, and the items that loaded on DF (-) were items that negatively impact the degree of flow (e.g., “I felt bored”). Because of the theoretical relationship between DF (+) and DF (-), responses on both factors were aggregated to form a score for the degree of flow. The score for degree of flow was computed by averaging DF Q1–DF Q14.

Discriminant validity. Discriminant validity seeks to establish that items on the assessment are not measuring unrelated constructs. The distinct difference in factor loadings between the two factors related to degree of flow and the two factors related to investigative self-efficacy suggest that the items are measuring different constructs.

Table 12

Factor Analysis Using Principal Component Analysis with Varimax Rotation

	DF(+)	**DF(-)**	**ISE F1**	**ISE F2**
ISE Q1	0.338	-0.16	0.435	0.431
ISE Q2	0.121	0.211	0.21	0.746
ISE Q3	0.173	0.156	0.75	-0.067
ISE Q4	-0.085	-0.017	0.698	0.129
ISE Q5	0.29	-0.223	0.569	0.085
DF Q1	0.795	0.146	0.028	0.112
DF Q2	0.868	-0.024	0.113	0.049
DF Q3	-0.1	0.853	0.051	0.009
DF Q4	0.881	0.005	0.085	0.086
DF Q5	0.492	0.374	0.187	-0.433
DF Q6	-0.012	0.81	-0.119	0.165
DF Q7	-0.101	0.859	-0.015	0.027
DF Q8	0.09	0.799	-0.004	-0.058
DF Q9	0.786	-0.097	0.22	-0.012
DF Q10	0.677	0.139	0.284	-0.292
DF Q11	0.887	-0.151	0.065	0.041
DF Q12	0.559	0.172	-0.11	0.342
DF Q13	0.875	-0.144	0.084	0.066
DF Q14	0.876	-0.112	0.083	0.023

Systematic validity. Systematic validity implies that the research and conclusions drawn from the results inform the questions that guided the research. An essential component to this process is a detailed description of the potential ways the researcher's philosophy or aspirations may impact the results. In this study, the researcher designed the intervention, implemented the intervention, and measured the outcomes.

The study was conducted in the public schools in the metropolitan area in which the researcher attended elementary, middle, and high school. Consequently, the researcher has close ties to the area and recognized some of the challenges the students faced. Some may argue that this relationship biased the researcher and negatively impacted the results. However, the researcher believes that prior experience in the context enriched the intervention and enabled her to establish relationships with after-school coordinators and students. To keep track of how previous experience impacted the researcher, at the end of each day of data collection, the researcher documented her experiences and feelings.

Reliability

Reliability across four data collection times of measurement was calculated using Cronbach's alpha. Cronbach's alpha for the measure of investigative self-efficacy was .91 and for degree of flow was .66. Determining an acceptable value for Cronbach's alpha involves a myriad of factors (Schmitt, 1996, p. 353), including the exploratory nature of study, multi-dimensionality of construct, and number of items on the assessment. A common accepted value is .6 and higher; consequently .91 and .66 are interpreted as acceptable levels.

Model Fit

A latent growth model (LGM) was used to explore the hypotheses. Latent growth models include both an intercept latent variable for means and a slope latent variable for growth. For each of the models, model fit was evaluated using root mean square estimation analysis (RMSEA) and square root mean residual (SRMR; see Table 13). RMSEA and SRMR were used because RMSEA is independent of sample size (Schermelleh-Engel, Moosbrugger, & Muller, 2003) and SRMR is sensitive to sample size. Thus, a good fit in both measures would suggest a “good” model fit. The criterion for a good model fit varies across disciplines and researchers. To provide an accurate and complete reporting of the results, the model fit statistics are reported here (see Table 13).

Table 13

Models, Fit Statistics, and Parameter Estimates for Effects of Type of Game and Learning Objectives

Hypothesis	Independent Variable	Dependent Variable	Chi-Squared (sig.)	DF	RMSEA (sig.)	RMSEA C.I.	SRMR
1a	Type of Game	Performance	9.88 (.27)	8	0.07 (.36)	.00 - .19	0.11
1b	Type of Game	Degree of Flow	5.51 (.79)	9	.00 (.84)	.00 - .11	0.09

Table 13 cont.

Hypothesis	Independent Variable	Dependent Variable	Chi-Squared (sig.)	DF	RMSEA (sig.)	RMSEA C.I.	SRMR
1c	Type of Game	Investigative Self-efficacy	5.73 (.68)	8	.00 (.75)	.00 - .14	0.16
2a	Learning Objectives	Performance	46.05 (.00)	9	0.30 (.01)	.22 - .39	1.04
2b	Learning Objectives	Degree of Flow	6.86 (.65)	9	.00 (.72)	.00 - .14	0.07
2c	Learning Objectives	Investigative Self-efficacy	7.14 (.52)	8	.00 (.61)	.00 - .16	0.14
2d	Learning Objectives, Performance, Degree of Flow	Investigative Self-efficacy	138.94 (.00)	71	.14 (.00)	.11 - .18	0.15

Hypotheses Testing

The goal of the first research question was to investigate the effects of playing an entertainment and stealth educational game on growth in player performance (Perf), growth in the degree of flow (Flow), and growth in investigative self-efficacy (ISE). To answer Research Question 1, three models were used to examined the effects of playing an entertainment or stealth educational game on growth in player performance (Perf), growth in the degree of flow (Flow), and growth in investigative self-efficacy (ISE; see Table 14).

Table 14

Path Coefficient, Standard Error, t statistic, and Effect Sizes for Testing Hypothesis Related to the Type of Game

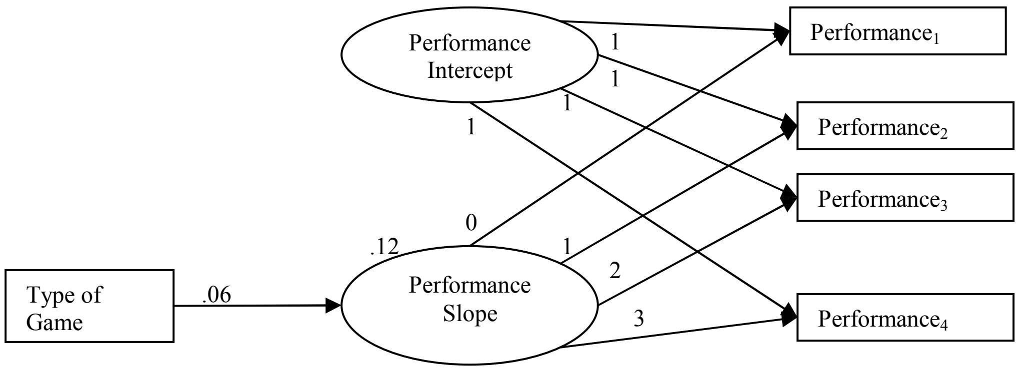
Hypothesis	IV	DV	b	SE	Est/SE	H_0	Sig	Effect Size
1a	Type of Game	Perf	0.06	0.03	2.14	E = S	0.03*	0.29
1b	Type of Game	Flow	0.00	0.03	-0.09	E = S	0.93	0.00
1c	Type of Game	ISE	-0.01	0.03	-0.36	E >= S	0.36	-0.05

* alpha < 0.10
E = Entertainment game
S = Stealth educational game
ISE = Investigative self-efficacy
Flow = Degree of Flow
Perf = Performance

Does the entertainment or stealth educational game affect growth in performance?

The null hypothesis was that the effect of the entertainment game on growth in performance would be equal to the effect of the stealth educational game on growth in performance. According to the significance level of the t-statistic, the effects of the entertainment and stealth educational games on growth in performance are statistically different ($t = 2.14$, $p = .03$, alpha = .10). Thus, the null hypothesis was rejected. Contradictory to the projected hypothesis, the entertainment game had a different effect on growth in performance than the stealth educational game. The path coefficient (.06) and effect size (Cohen d = .29) suggest that when compared to the entertainment game, the stealth educational game had a small positive effect on growth in performance (slope =.12; see Figure 8).

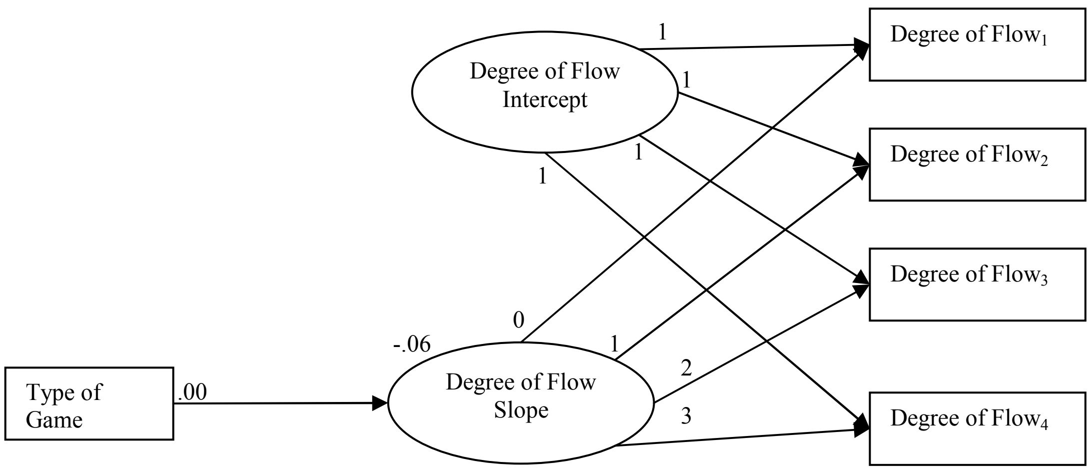
Figure 8. Path model for answering the question does the type of game affect growth (slope) in performance.



Does the entertainment or stealth educational game affect growth in degree of flow?

The null hypothesis was that the effect of the entertainment game on degree of flow would be equal to the stealth educational game. The significance level revealed that the effect of the entertainment game on growth in degree of flow might be similar to the stealth educational game ($t = -.09$, $p = .93$, alpha = .10). The null hypothesis could not be rejected. As projected, the entertainment and stealth educational games had a statistically similar effect on growth in degree of flow. When compared to the stealth educational game, the path coefficient (.00) and effect size (Cohen's d=.00) suggest that the entertainment and stealth educational games did not affect growth in degree of flow (slope=-.06; see Figure 9).

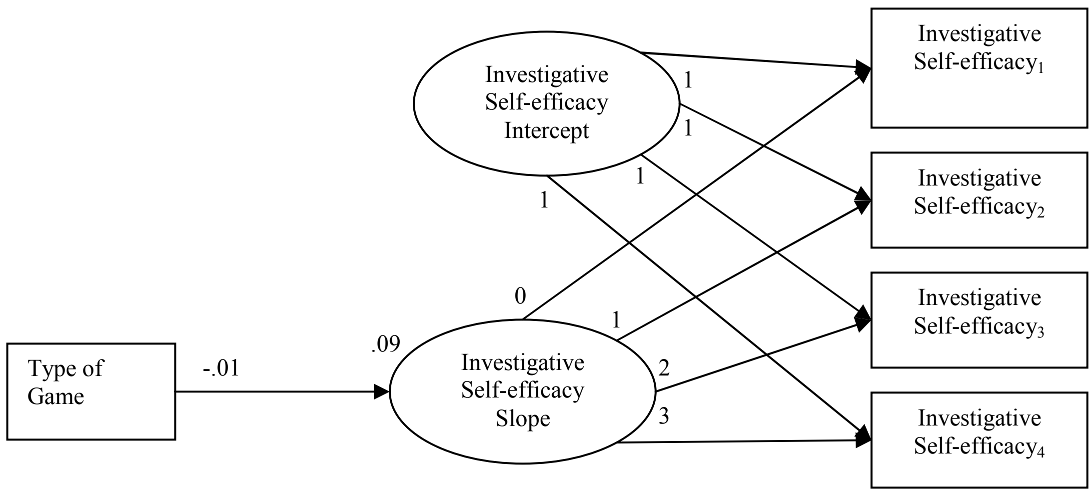
Figure 9. Path model for answering the question does the type of game affect growth (slope) in degree of flow.



Does the entertainment or stealth educational game affect growth in investigative self-efficacy?

The null hypothesis was that the effect of the entertainment game on investigative self-efficacy would be greater than or equal to the stealth educational game. The significance level revealed that the effect of the entertainment game on investigative self-efficacy may be statistically greater than or equal to the stealth educational game ($t = -.36$, $p = .36$, alpha = .10). The null hypothesis could not be rejected. Contradictory to the projected hypothesis, the entertainment game's effect on growth in investigative self-efficacy may be equal to or greater than the stealth educational game. The path coefficient (-.01) and effect size (Cohen d = -.05) suggest that the entertainment game had a small negative effect on growth in investigative self-efficacy (slope =.09; see Figure 10).

Figure 10. Path model for answering the question does the entertainment game have a greater affect than stealth educational game on growth (slope) in investigative self-efficacy.

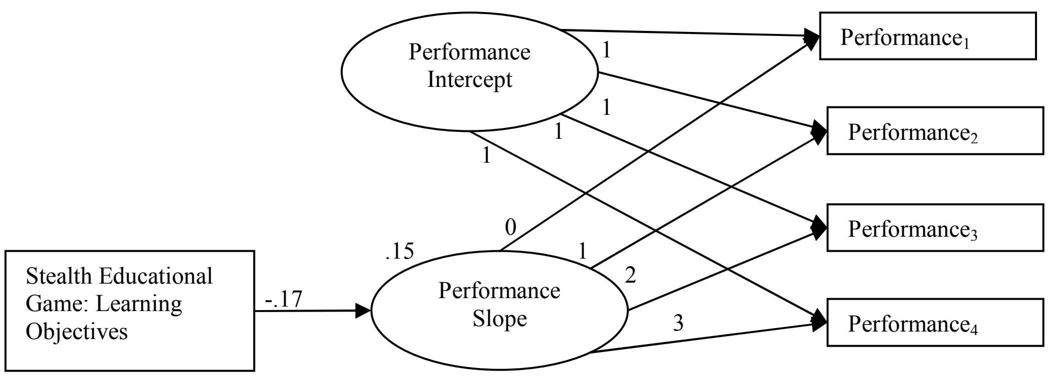


Research Question 2 explored how stated and unstated learning objectives while playing a stealth educational game affect the growth in performance during a stealth educational game (Perf), the degree of flow during a stealth educational game (Flow), and investigative self-efficacy (ISE; see Table 15).

When playing the stealth educational game, is the unstated learning objectives effect on growth in performance greater than the stated learning objectives effect on growth in performance?

The null hypothesis was that the effect of the stated learning objectives on growth in performance would be less than or equal to the unstated learning objectives. According to the significance level, stated learning objectives' effects on growth in performance may be less than or equal to the effect of the unstated learning objectives ($t = -3.49$, $p = 1$, alpha = .10). Thus, the null hypothesis cannot be rejected. As projected, the effects of stealth educational games' unstated learning objectives on growth in performance may have been greater than the stealth educational games' stated learning objectives. According to the path coefficient (-.17) and effect size (Cohen d = -.50), when compared to the unstated learning objectives the stated learning objectives had a moderate negative effect on growth in performance (slope = .15; see Figure 11).

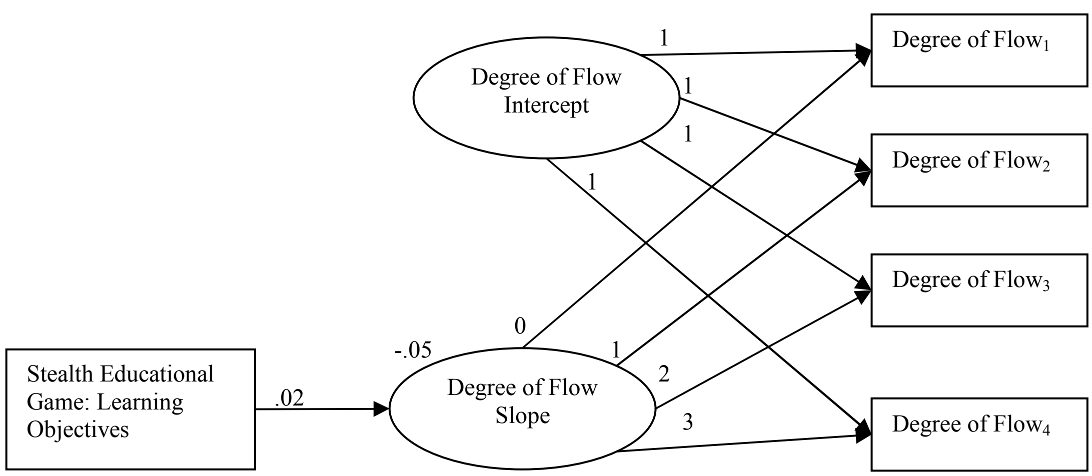
Figure 11. Path model for determining if when playing a stealth educational game, unstated learning objectives have a greater affect than stated learning objectives on growth (slope) in performance.



When playing the stealth educational game, is the unstated learning objectives effect on growth in degree of flow greater than the stated learning objectives effect on growth in degree of flow?

The null hypothesis was that the effect of stated learning objectives on growth in degree of flow would be less than or equal to unstated learning objectives. The significance level revealed that stated learning objectives' effects on growth in degree of flow may be less than or equal to effects of unstated learning objectives ($t = .07$, $p = .63$, alpha = .10). The null hypothesis cannot be rejected. As projected, the effects on the growth in degree of flow from stealth educational games' unstated learning objectives may have been greater than the stealth educational games' stated learning objectives. According to the path coefficient (.02) and effect size (Cohen's $d = .07$), when compared to the unstated learning objectives the stated learning objectives had a small positive effect on growth in degree of flow (slope=-.05; see Figure 12).

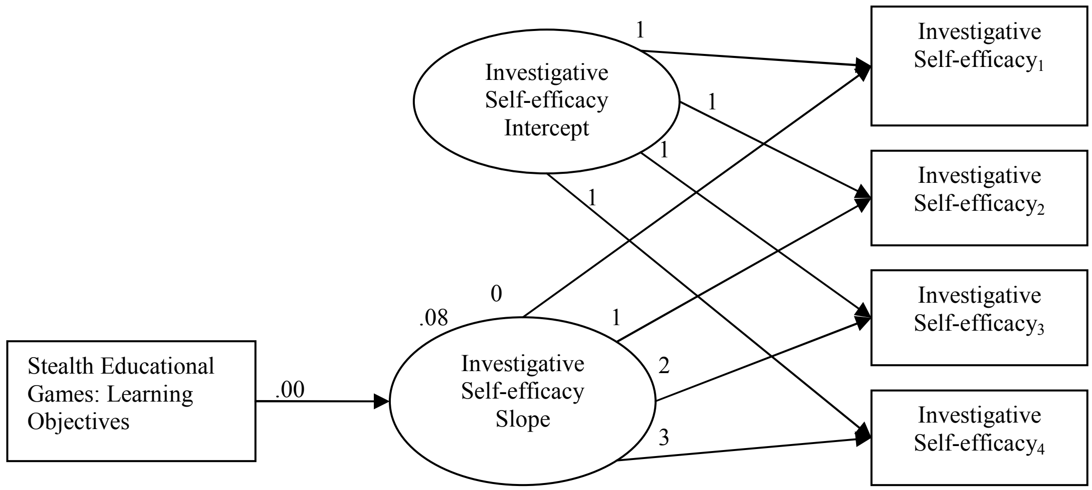
Figure 12. Path model for determining if when playing a stealth educational game, unstated learning objectives have a greater affect than stated learning objectives on growth (slope) in degree of flow.



When playing the stealth educational game, is the unstated learning objectives effect on growth in investigative self-efficacy greater than the stated learning objectives effect on growth in investigative self-efficacy?

The null hypothesis was that the effect of the stated learning objectives on growth in investigative self-efficacy would be less than or equal to the unstated learning objectives. The significance level revealed stated learning objectives' effect on investigative self-efficacy may be statistically less than or equal to unstated learning objectives ($t = .00$, $p = .50$, alpha = .10). The null hypothesis cannot be rejected. As projected, when playing the stealth educational game the effects of unstated learning objectives' may be greater than the effect of stated learning objectives on growth in investigative self-efficacy. According to the path coefficient (.00) and effect size (Cohen's d=.00), when compared to the stated learning objectives, the unstated learning objectives did not affect growth in investigative self-efficacy (slope=.08; see Figure 13).

Figure 13. Path model for determining if when playing a stealth educational game, unstated learning objectives have a greater affect than stated learning objectives on growth (slope) in investigative self-efficacy.



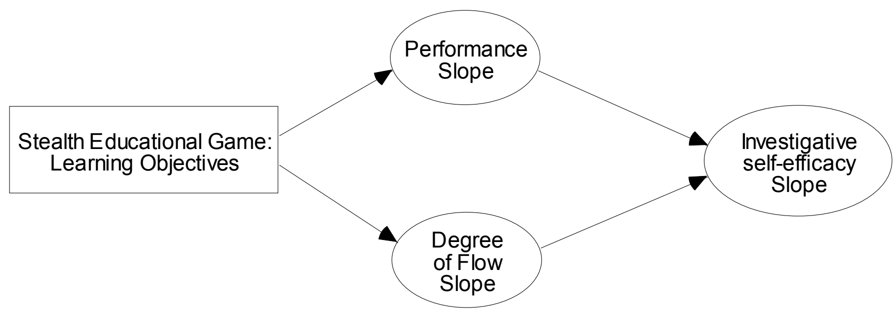
When playing the stealth educational game is the effect of the learning objectives on growth in investigative self-efficacy completely mediated by growth in performance and degree of flow?

Baron and Kenny (1986) recommended four steps to test mediation. The first step is to establish a relationship between dependent variable, in this case learning objectives, and the dependent variable, investigative self-efficacy. To examine the direct effect between these two variables, the researcher reviewed the significance level for a two-tailed test of the effect of learning objectives on investigative self-efficacy ($p = .00$, alpha = .10), which suggests that the stated learning objectives' effects on investigative self-efficacy are not statistically different from the unstated learning objectives (see Figure 14).

In step two, the goal is to establish relationships among the independent variable, which is the learning objective, and the mediating variables, which are performance and degree of flow. There is a statistically significant difference between the effect of unstated learning objectives on growth in performance (.00, alpha = .10) and stated learning objectives. There is not a statistical significant difference between the effect of unstated learning objectives on growth in degree of flow ($p = .45$, alpha = .10) and stated learning objectives. Stated learning objectives have a moderate negative effect on performance, -.50. Stated learning objectives have a small effect on degree of flow, .10.

The third and final step is to establish a relationship between the mediating variables and the dependent variables. Performance does not have a statistically significant effect on investigative self-efficacy (p = .28, alpha = .10) with a small effect on investigative self-efficacy (Cohen's d = .16). Degree of flow does not have a statistically significant effect on investigative self-efficacy (p = .28; alpha = .10) with a small effect on the dependent variable, investigative self-efficacy (Cohen's d = .16).

Figure 14. Path model for determining if when playing a stealth educational game, learning objectives affect on growth (slope) in investigative self-efficacy is completely mediated by growth (slope) in performance and degree of flow.



Since there is no effect between the independent variables and the mediating variables, the mediating variables and the dependent variables, or the independent variables and the dependent variables, the effect of learning objectives on investigative self-efficacy cannot be mediated by growth in performance and degree of flow. Thus, the hypothesis for Research Question 2 was not supported. The effect of the learning objectives was not mediated by growth in performance and degree of flow (see Table 15).

Table 15

Path Coefficient, Standard Error, t statistic, and Effect Sizes for Testing Hypotheses Related to Stealth Educational Game and Learning Objectives

		DV	b	SE	Est/SE	H_0	Sig.	Effect Size
2a	LO	Perf	-0.17	0.05	-3.49	S <= U	1.00	-0.50
2b	LO	Flow	0.02	0.04	0.53	S <= U	0.59	0.07
2c	LO	ISE	0.00	0.05	0.01	S <= U	0.50	0.00
2d	LO	Perf	-0.17	0.05	-3.49	S = U	0.00*	-0.50
	LO	Flow	0.00	0.03	0.07	S = U	0.94	0.07
	Perf	ISE	0.83	0.78	1.08	Slope=0	0.28	0.16
	Flow	ISE	9.46	8.69	1.09	Slope=0	0.28	0.16
	LO	ISE	0	0.05	0.01	S = U	0.99	0.00

* alpha < .10
U = Unstated learning objectives
S = Stated learning objectives
LO = Learning Objectives
ISE = Investigative self-efficacy
Flow = Degree of Flow
Perf = Performance

Discussion

The effect of the type of game and learning objectives on growth in performance, degree of flow, and investigative self-efficacy varied from no effect on growth to a moderate effect on growth. When compared to the entertainment game, the stealth educational game had a small positive effect on growth in performance and no effect on growth in degree of flow. When compared to the stealth educational game, the entertainment game had a small negative effect on growth in investigative self-efficacy.

For the stealth educational game, unstated learning objectives had a small positive effect on growth in performance and a small negative effect on degree of flow. However, neither unstated nor stated learning objectives affected growth in investigative self-efficacy.

Type of Game: Entertainment vs. Stealth Educational

Performance in games. Performance in the stealth educational game depended on participants' choices and actions; if a participant was not actively manipulating objects in the stealth educational game, nothing happened. However, in the entertainment game, participants could earn points by making unsystematic decisions and then waiting on the game to execute pre-programmed algorithms. The small positive effect of stealth educational games on growth in performance, when compared to the entertainment game, might be explained by the stealth educational game's attribute of requiring players to apply complex rules in a multivariate environment. This attribute facilitates active engagement and critical thinking and gives players the opportunity to practice and improve.

Degree of flow. When compared to the entertainment game, the stealth educational game had no affect on growth in degree of flow. The lack of effect may be attributed to participants' belief that the stealth educational game was too hard. While playing the stealth educational game, participants made comments that suggested the stealth educational game was too hard, such as "Miss, I can't do it. Can Sara do it for me?" or "Miss, this is too hard." Based on these comments, it is not surprising that when compared to the entertainment game, the stealth educational game did not affect growth in degree of flow games.

Investigative self-efficacy, The entertainment game had a small negative effect on growth in investigative self-efficacy, when compared to the stealth educational game. The entertainment game did not require players to explore, understand, predict, or control events, which are key components in the definition of investigative self-efficacy. Thus, the lack of positive effect on growth in investigative self-efficacy, when compared to the stealth educational game which did include components of investigation, is not surprising.

Stealth Educational Game: Learning Objectives

Performance in game. A comparison of stealth educational game stated learning objectives and stealth educational game unstated learning objectives revealed that stealth educational game stated learning objectives negatively affected growth in performance and that the effect of unstated learning objectives on growth in performance was greater than the stated learning objectives. This finding supports Berry and Broadbent's (1988) findings, which suggested that implicit learning objectives in complex multivariate environments have a greater positive effect on performance than explicit learning objectives. Thus, unstated learning objectives might be appropriate in informal learning environments.

Degree of flow. Stealth educational game stated learning objectives positively affected growth in degree of flow when compared to the unstated learning objectives. This finding supports the argument that students are not opposed to education. Perhaps in informal learning environments located in public schools (e.g., after-school programs), educational activities that are entertaining are more engaging than purely entertaining activities. The priorities and values of the public school staff and administrators, who are often present during after-school activities, might have impacted participants' priorities and values.

Investigative self-efficacy. When compared to the unstated learning objectives, the stated learning objectives did not affect growth in investigative self-efficacy directly or indirectly through personal experience. Personal experience was operationally defined as performance and degree of flow. Since personal experiences' effect on self-efficacy is well documented, the lack of indirect effect on investigative self-efficacy could have one of two explanations: one, the operational definition is not adequate, or two, perhaps the self-efficacy built by the game did not transfer to investigative self-efficacy.

According to results of participants who played the stealth educational game, growth in performance had only a small effect on growth in investigative self-efficacy. The results support self-efficacy theory, which says that failures and successes affect self-efficacy; in particular, mastery experiences builds self-efficacy (Bandura, 1986). This small effect suggests that the activities in the stealth educational game were aligned with activities that reflect investigative self-efficacy.

Growth in the degree of flow did not affect growth in investigative self-efficacy. The results imply that the degree of flow is an inadequate definition of personal experience. Eccles and Wigfield (2002) argued that flow reflects task value rather than personal experience. They proposed that expectancy beliefs (i.e., self-efficacy) and value (i.e., flow) are highly correlated but that there is not a causal relationship. Based on the lack of effect, Eccles and Wigfield's (2002) expectancy-value model may be a more appropriate theoretical basis than flow theory for exploring the effects of computer games on pre-teens' self-efficacy.

Stated learning objectives lack of direct effect on growth in investigative self-efficacy contradicts the results in the six studies discussed in the literature review. These six studies suggested that computer games have a small to moderate effect on self-efficacy. The differences between the previous research studies and this study, along with the opposite findings, suggest that computer games' effect on self-efficacy is conditional. Some of the conditions include the cognitive development of the participants, the domain of the self-efficacy, and the research setting.

Cognitive development occurs as a result of the natural aging process and through specific experiences. Hence, pre-teens' cognitive development is distinctly different from college-aged students. The cognitive differences between the populations can be described in multiple attributes. Two attributes that can have a significant impact on a research study's results are goal-orientation and meta-cognitive abilities.

Goal-orientation refers to a person's behavior and approach to various tasks or goals (Wigfield & Eccles, 2001). Dweck (1999) classified the various approaches and behaviors into two main areas—learning and performance orientations—where learning refers to a desire to master a task and performance refers to a desire to complete a task. Performance orientation is further broken down into approach and avoidance, where performance-approach implies engaging in an activity in order to complete a task and performance-avoidance implies avoiding an activity in order to avoid appearing unintelligent.

In elementary-aged students and pre-teens, goal-orientation is less stable than in college-aged students (Wigfield & Eccles, 2001). Pre-teens' goal-orientations are more dependent on external characteristics such as the environment or peers than on internal characteristics. In this study, the impact of the environment could be seen through participants' behaviors as they played the game. At one school, participants would call out to the group and celebrate when a classmate passed a challenging level. At another school, a small group of participants experienced success and quietly enjoyed the game, while most of the participants constantly complained that it was too hard. This difference in environment and its potential impact on behavior and approach to tasks suggest that research involving pre-teens should consider and evaluate the environment qualitatively to appraise how it may impact the results.

Meta-cognitive abilities refer to a person's ability to understand, control, and regulate his or her cognitive processes. Pre-teens' meta-cognitive abilities are less developed than those of college-aged students (Kuhn, 2000). Environmental influences, peers, or daily activities are more likely to impact effort, enjoyment, and performance throughout the day. In this study, the lack of meta-cognitive development was observed as some participants became increasingly frustrated with their lack of success and yet continued to constantly execute the same strategy (i.e., drawing a flat line in Scriball). A few students applied the same unsuccessful strategy until they were asked a question about their strategy. Hence, the results of research conducted with pre-teens are shaped by their meta-cognitive abilities.

The previous literature focused on health-related self-efficacy, while this study focused on investigative self-efficacy. The impact of tasks related to a person's health is more concrete and more readily apparent than the impact of tasks related to investigative self-efficacy. For example, in this study, one of the questions on the investigative self-efficacy assessment asked students how good they were at taking things apart. Conceptually, pre-teens in this study did not understand the question. Participants at each school asked the researcher to explain this question. Conceptual understanding of the domain and the domain's relevance to the participant may impact computer games' effects on self-efficacy.

This study was conducted in local after-school programs as opposed to post-secondary institutions, like the previous research studies. Participants in the previous research studies chose to attend the institutions at which the studies were conducted and were intrinsically motivated to learn. Conversely, participants in this study attended the after-school program because of their parents' schedules and were usually assigned to activities based on limited options. This suggests that potential participants' sense of control and the number of options available to them should also be considered when conducting research in a real-world setting.

The lack of effect on investigative self-efficacy also suggested that performance and degree of flow could not mediate the relationship between the learning objectives and investigative self-efficacy because the relationship did not exist.

Although the results suggest that neither the type of game nor learning objectives affect growth in investigative self-efficacy, the results do suggest that stealth educational game unstated learning objectives do have a positive effect on growth in performance and also that stealth educational game stated learning objectives positively affect growth in degree of flow or engagement. Thus, stealth educational game stated learning objectives might have a place in informal learning environments.

Conclusions

An interest in increasing minorities' interest in science careers motivated this study. However, this study did not examine computer games' effects on career choices. Rather, this study focused on stealth education games' effects on investigative self-efficacy because the relationship between investigative self-efficacy and science careers is well established. When compared to the stealth educational game, the entertainment game had a different effect on growth in performance, a similar effect on growth in performance, and a small negative effect on growth in investigative self-efficacy. Whereas data collected while playing the stealth educational game suggested that unstated learning objectives had a small positive effect on growth in performance and a small negative effect on degree of flow. However, neither unstated nor stated learning objectives affected growth in investigative self-efficacy. The small to moderate effects of this study inform theory and research as well as practitioners and future researchers.

Informing Theory

Attention, flow, and self-efficacy theories formed the basis of this study's theoretical framework. These three theories were used to define constructs and justify relationships among constructs as well as develop hypotheses.

Attention Theory

Attention theory suggests that recurring and repeated practice playing computer games impacts the development of selective attention and, as a result, influences future personal experience. Based on this proposition, the researcher hypothesized that pre-teens' prior experience playing entertainment games would be reflected in the effects of two factors on personal experience: (1) the type of computer game, and (2) stated and unstated learning objectives. As previously mentioned, personal experience was defined using two constructs: (1) performance, and (2) degree of flow.

The results in this study suggest that the relationship between prior experience and future personal experience needs further refinement. In this study, the hypotheses assumed that existence and prevalence of prior experiences with computer games would be sufficient to influence succeeding enjoyment of the game and performance. Instead, the small effect sizes suggest that the quality and results of prior experience along with the situational attributes of those experiences may significantly influence subsequent engagement or flow.

Flow Theory

Flow theory defines and describes qualities of optimal experiences. According to the theory, an optimal experience or the flow state includes feelings of immersion, self-confidence, a sense of mastery, and control. As a result, the flow state leads to sustained concentration and effort. The flow state is arguably a desired state that is actively pursued by all humans. Based on these propositions, the researcher operationally defined personal experience as the degree of flow, expecting that a higher degree of flow would reflect a more positive personal experience. Flow may be more appropriately labeled a task value rather than a reflection of personal experience.

Self-Efficacy Theory

Self-efficacy theory describes the sources and development of self-efficacy. Self-efficacy is a person's belief in his or her ability to accomplish a specific task or goal. The most dominant source of self-efficacy is personal experience. Thus, the researcher hypothesized that personal experience would affect self-efficacy. Accordingly, the researcher operationally defined personal experience using performance, as well as the aforementioned degree of flow construct, and hypothesized that both of these constructs would affect investigative self-efficacy.

The results illustrated that neither the type of game, stated and unstated learning objectives, nor personal experience, as defined, affected investigative self-efficacy. This study's results suggest that personal experience operationally defined only in terms of constructs in a computer game is not sufficient. Other aspects of personal experience internal to the person and external to the game should also be used to define personal experience when exploring computer games' effects on self-efficacy.

Informing Research

This study was conducted with a different audience (e.g., pre-teens) within a different setting (e.g., local after-school program) in a different domain (e.g., investigative) than the six systematically identified studies. Additionally, contrary to the results from previous studies and the hypotheses in this study, the results of this study provide evidence that regardless of their popularity, in informal learning environments, computer games do not positively affect minority pre-teens' investigative self-efficacy.

Current Body of Research. The current research on computer games' effects on self-efficacy is primarily focused on the health-related self-efficacy of college-aged students associated with post-secondary education institutions and shows small to moderate effects on health-related self-efficacy. Conversely, this study was conducted with minority pre-teens in local after-school programs, and the results suggest that computer games have do not have a positive effect on investigative self-efficacy.

Berry and Broadbent's (1988) Comparative Study. The results in this study support the findings reported by Berry and Broadbent (1988). Berry and Broadbent's (1988) results suggest that in complex multivariate systems, implicit instructions have a more positive effect on performance than explicit instructions do. Their results imply that the effect of implicit and explicit instructions on performance depends on the complexity of the environment in which the participant performs. The findings of this study suggest that even when the difficulty level of the task is progressive, rather than fixed, implicit instructions have a greater effect on performance than explicit instructions.

Both Berry and Broadbent's (1988) study and this study asked participants repeatedly to achieve a specific state. However, the studies differed in their approaches. In Berry and Broadbent's (1988) study, during each trial, the task had the same difficulty level. In contrast, in this study, tasks grew progressively harder. Also, in the Berry and Broadbent (1988) study, during each trial, participants were asked to not only achieve but also maintain a specific state. Conversely, in this study, participants were asked to achieve a specific state but not to maintain it. In fact, once the desired state was achieved, they moved to a harder level and tried to achieve the desired state again. The effect of unstated learning objectives' on performance persisted while increasing the task's degree of difficulty.

Informing Practice

There has been a lot of discussion and debate about the potential and appropriate use of computer games. The popularity of this medium with pre-teens makes it attractive to many practitioners who work with pre-teens. The untapped potential of this medium was an underlying reason for this study. It was conducted in an informal learning environment (e.g., local after-school programs) and utilized easily accessible games (e.g., Web-based games). Consequently, the findings of this study inform practitioners in after-school programs and designers of Web-based games.

After-school program staff or volunteers who are responsible for designing or selecting computer games should base their decisions primarily on the configuration of computers, appropriateness of game content, progression of difficulty of game tasks, complexity of the game environment, and availability of the computer game. This process will identify both entertaining and educational games that appeal to the students. If the game is to be used for entertainment and not an enrichment activity, this process is sufficient. According to the results in this study, minority pre-teens will enjoy the educational games just as much as they enjoy entertainment games, and neither will have a significant effect on performance or self-efficacy. If the game is to be used in an enrichment activity, the after-school program staff or volunteers should also consider the explicitness of the learning objectives integrated into the game play and the amount of time available to play the game. It may be that explicit learning objectives in the computer game and more than two hours of game playing across four days would positively influence personal experience and, consequently, investigative self-efficacy.

Game designers should base their decisions on their ultimate goal of providing entertainment or education to players when designing and developing Web-based games for pre-teens. Best practices include researching the habits and likes of pre-teens, including various elements of fun, and varying levels of difficulty. For educational ventures, this includes designing games based on learning objectives. The findings of this study indicate that unstated learning objectives have a more positive effect on growth in performance than stated learning objectives, a negative effect on growth in degree of flow, and no effect on growth in investigative self-efficacy. The decision of when to use implicit or explicit learning objectives depends on the purpose of the game.

Limitations

The sample size, setting, participants, and the games themselves limited this study. The small sample size makes the results susceptible to sampling error, which makes it difficult to achieve statistical significance. However, the small effect sizes suggest that even a large sample might not have achieved statistical significance. The unequal sample sizes may have also confounded the results. However, latent growth model analysis deals with unequal group sizes as it does missing data; thus, the effects of the unequal group sizes may have been mitigated. The lack of effect on investigative self-efficacy may be attributed to the previously discussed difficulty for participants' to transfer investigative self-efficacy gained from gaming to other contexts.

The results of the studies can only be generalized to participants who developed in cultures and neighborhoods similar to participants in this study. The study was conducted in the after-school programs of elementary public schools in a metropolitan city in Texas. The students at these elementary schools were predominantly minorities, and most students qualified for free or reduced lunches. The culture and neighborhoods of these students influenced their motivation, behavior, experiences, and expectations regarding gaming and informal learning environments in general.

The games used in this study were Web-based flash games with two-dimensional graphics. The games were designed for computers. The computers did not require high-end graphic cards or a lot of memory. Thus, the results of this study can only be generalized to similar games. Games that are played on consoles or include three-dimensional graphics may have a different effect.

Future Research

As this is the first study investigating the effects of computer games on pre-teens' investigative self-efficacy, more evidence is needed before conclusions can be drawn regarding games' effects across age levels and domains. This study's design and implementation neglected to systematically define the environment of each school, limited the amount of game playing to two hours across four days, and asked participants to complete the same 19-question Likert-scale survey each of the four days. Future research should employ theory to systematically document and define the environment in which the game is delivered, incorporate assessments built into the game instead of using surveys, include incentives for student participation and obedience, and compare the effects of three types of games: an entertainment game, a stealth educational game, and an explicitly educational game.

CHAPTER V

CONCLUSIONS

This work was based on the premise that the recurring personal experiences that minority adolescents choose to have with computer games provides a potential avenue to affect investigative self-efficacy. To investigate the opportunity presented by computer games, this dissertation systematically identified and synthesized literature that explored computer games' effects on self-efficacy, explored and integrated three theories and an empirical study to identify attributes to be included in a computer game when the purpose is to increase investigative self-efficacy, and tested the theoretical framework in a real-world setting. The attributes under investigation were type of computer game and learning objectives.

The systematic literature review revealed a gap in the literature. The researcher systematically identified only six studies published between 1995 and 2009 that examined computer games' effect on self-efficacy. The limited settings and participants confounded the challenges and gap presented by the small number of studies. These six studies were based on a variety of theories (e.g., situated learning, video game-based learning, health behavior theories, etc.). The common thread across the six studies was the belief that computer games were engaging and could sustain the attention of learners. This common thread combined with the known relationship between self-efficacy and career choices led to an exploration of theories related to engagement, motivation, performance, and self-efficacy. The culmination of this exploration was the development of a theoretical argument based on three theories—attention, flow, and self-efficacy—and an empirical study by Berry and Broadbent (1988).

Attention, flow, and self-efficacy theories combined with Berry and Broadbent's (1988) findings on implicit instruction and performance formed the theoretical framework. That framework described the four attributes in computer games needed to build investigative self-efficacy: (1) unstated learning objectives, (2) learning tasks that support the objectives hidden in the game play, (3) a focus on entertaining the player, and (4) the requirement of the player to apply complex rules in a multivariate system. These four attributes define stealth educational games.

The empirical study in this dissertation tested the effects of an entertainment game and a stealth educational game on growth in performance, degree of flow, and investigative self-efficacy. Additionally, the study examined the effects of unstated and stated learning objectives when playing a stealth educational game on growth in performance, degree of flow, and investigative self-efficacy.

Applying the theoretical argument in three public elementary schools' after-school programs revealed that the type of game as well as stated and unstated learning objectives both had statistically significant effects on growth in performance and neither had a statistically significant effect on growth in degree of flow or investigative self-efficacy. Even though not statistically significant, the type of game and learning objectives both had effects on growth in performance and degree of flow according to the effect sizes. However, neither had an indirect or direct effect on growth in investigative self-efficacy.

Informing Theory

The findings of the systematic literature review in Chapter II and the quasi-experimental study Chapter IV both inform theory. The authors of the six studies identified during the systematic literature review were based on a variety of theories such as game-based learning, social cognitive theory, self-concepts, etc. In four of the six studies, researchers used social cognitive theory or self-efficacy as the framework. They focused on the relationship between personal master experience and self-efficacy. Each of these studies had a small-to-moderate effect on self-efficacy. These results suggest that these theories support the premise that computer games can affect self-efficacy.

The theoretical framework of the quasi-experimental study reported in Chapter IV was based on attention, self-efficacy, and flow theories. Unfortunately, the interventions in the quasi-experimental study did not affect growth in investigative self-efficacy. Like the studies described in the systematic literature review, the relationship between personal experience and self-efficacy was the focus. In the quasi-experimental study, personal experience was operationally defined using both self-efficacy and flow theories. The results suggest that flow is not an appropriate operational definition of personal experience.

Informing Research

The theoretical argument in Chapter III along with the results of the quasi-experimental study Chapter IV informs research. The theoretical argument presents a case for using implicit learning objectives rather than explicit learning objectives. This argument is based largely on the results of Berry and Broadbent's (1988) study, which reported that implicit instructions had a more positive impact than explicit instructions on performance. This argument is supported by the results of the quasi-experimental study. Findings suggest that stealth educational games had a more positive effect than entertainment games on growth in performance. In order to determine, if implicit learning objectives have a place in effective research more research needs to be done.

Limitations

The impact of this dissertation is limited by the article identification procedures in the systematic literature review and the setting of the empirical study. To identify the six articles in the literature review, the researcher searched four indexes/databases using specific criteria. This approach may have excluded some relevant articles. Using the limited literature available, the researcher identified potential concepts and theories to explain the relationship between computer games and self-efficacy. The theoretical framework that was developed as a result excluded theories related to values and instead focused on concepts and theories related to attention, flow, self-efficacy, and implicit instruction. The integration of these concepts and theories led to the definition of stealth educational games and the operational definition of personal experience.

Another potential limitation is the setting, small sample, and unequal group sizes of the quasi-experimental study. The study was conducted with minority students in a metropolitan city. Although all the schools were in the same school district, the differences across schools were pronounced. These differences in the settings may have impacted the results of the study. It also impacts the generalizability of the results. The small sample and unequal group sizes may have also confounded the results. Any differences between groups may have been caused by a number of factors. The small sample size and unequal group sizes increases the likelihood that there is a common thread in the sample that may have impacted the results. The sample makes it difficult to ensure that it is the intervention and not group characteristics that influenced the results.

Implications for Practice

This dissertation speaks to a gap in the literature and the findings contest a long-held view in instructional design. The empirical study in this dissertation examined the effect of computer games on investigative self-efficacy, rather than health-related self-efficacy, and participants were elementary school students, rather than college-aged students. The findings of the empirical study suggest that unstated learning objectives rather than stated learning objectives may be appropriate in stealth educational computer games. This finding contests a long-held view and practice in instructional design that recommends sharing learning objectives with learners. The findings impact educational game designers, operational definitions, and theory.

Designing an educational game is a creative process (Hirumi, Appelman, Rieber, & Van Eck, 2010). During the process, designers should “design a game, play a game, and revise the game until one reaches an optimal blend of fun and learning” (Hirumi et al., 2010, p. 25). The stealth educational game in this study did not produce the optimal blend of learning and fun. According to the results in the empirical study, for the stealth educational game, unstated learning objectives had a more positive effect on growth in performance than stated learning objectives and a small negative effect on growth in degree of flow. Unlike the entertainment game, the stealth educational game did not include a narrative story. Hirumi, Appelman, Rieber and Van Eck (2010) argued that a good game begins with a good story. Based on this finding and Rieber's recommendations, one more attribute should be added to the four attributes that define stealth educational games, and that is that stealth educational games should begin with a good story. When designing a stealth educational game, designers should begin with a good story and proceed with the other four attributes: (1) unstated learning objectives, (2) hidden supporting learning tasks in the game play, (3) a focus on entertaining the player, and (4) the requirement of the player to apply complex rules in a multivariate system.

In the empirical study, participants played Web-based two-dimensional games for two hours across four days. The findings indicate that neither type of game nor learning objectives had a positive effect on growth in investigative self-efficacy. The effect was tested directly and indirectly through personal experience. These findings suggest that the operational definition of personal experience should be revised, a different theoretical framework might be more appropriate for testing the effects of computer games on self-efficacy, and when designing stealth educational games, designers should consider the amount of playing time.

Performance and degree of flow operationally defined personal experience. Since the relationship between personal experience and self-efficacy is well established, these results suggest that the operational definition of personal experience might be inadequate and/or perhaps more practice variability is needed in order for the self-efficacy developed in the game to transfer outside of the game.

Assuming the operational definition of personal experience is inadequate, Eccles and Wigfield’s (2002) expectancy-task-value model may be an appropriate theoretical framework. According to Eccles and Wigfield’s expectancy-task-value model, expectancy and task value are directly related and both influence performance. According to their model, flow represents the intrinsic value of a task, rather than personal experience, and self-efficacy represents expectancy. Therefore, personal experience might be better defined by performance alone rather than performance combined with degree of flow.

Eccles and Wigfield’s model also supports practice variability, which promotes self-efficacy generalization (Cervone, 2000; Holladay & Quiñones, 2003; Pugh & Bergin, 2006). Practice variability implies that the environment and activity change as a person practices. Their model stresses importance of repeated experience and time for development. The two factors, repeated experience and time, provide opportunity for practice variability. Perhaps the complexity of the game combined with the short amount of game playing did not provide enough practice or variability for self-efficacy to generalize. When designing stealth educational games, designers should consider how much time a player will need to play the game in order to achieve optimal learning.

Future Research

Future studies should validate and extend the results of this dissertation by exploring factors in new theoretical frameworks and conducting research in a similar environment with minority students. This dissertation focused on flow theory and used degree of flow as an operational definition of personal experience. Since mastery experiences are known to build self-efficacy (Bandura, 1986), it might be more appropriate to define personal experience using constructs that reflect failure and success. Flow is a reflection of intrinsic value, rather than success or failure (Csíkszentmihályi, 1990; Eccles & Wigfield, 2002). Degree of flow should be used to operationally define task value, rather than personal experience, as recommended by Eccles and Wigfield (2002). Future explorations need to be conducted into the interrelationships among factors that contribute to growth in investigative self-efficacy. Tweaking the theoretical framework and conducting research in similar environments will address the gap in the literature and could also deepen understanding of the potential of games for affecting minority students' investigative self-efficacy.

This dissertation was motivated by a desire to increase minorities' interest in science careers and to capitalize on the prevalence of computer games in today's society. The military capitalizes on the strengths of computer games by using them to train troops for critical and dangerous missions. The decisions and quantity of variables that must be considered for military missions are more complex than what is required of our students in science classrooms. Surely, we as researchers and educational game designers can find a way to tap into the potential of games to address critical gaps in our nation's workforce.

REFERENCES

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Baron R., M., & Kenny D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psycholog*y, *51*, 1173–1182.

Bassett-Jones, N. (2005). The paradox of diversity management, creativity and innovation. *Creativ-ity and Innovation Management*, *14*, 169-175.

Behm-Morawitz, E., & Mastro, D. (2009). The effects of the sexualization of female video game characters on gender stereotyping and female self-concept. *Sex Roles*, *61*(11), 808-823.

Berry, D. C., & Broadbent, D. (1988). Interactive tasks and the implicit, explicit distinction. *British Journal of Psychology*, *79*(2), 251-272.

Betz, N. E., & Hackett, G. (2006). Career self-efficacy theory: Back to the future. *Journal of Career Assessment*, *14*(1), 3-11.

Broadbent, D. E. (1958). *Perception and communication.* Oxford: Pergamon Press.

Brown, S., Lieberman, A., Gemeny, B. A., Fan, Y. C., Wilson, D. M., & Pasta, D. J. (1997). Educational video game for juvenile diabetes: Results of a controlled trial. *Medical Informatics*, *22*(1), 77-89.

Cervone, D. (2000). Thinking about self-efficacy. *Behavior Modification*, *24*(1), 30-56.

Chen, J. (2007). Flow in games (and everything else). *Communications of the ACM*, *50*(4), 31-34.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper & Row.

Debose Columbus, Y., & Cifuentes, L. (2010). *The effect of computer games on self-efficacy*. Manuscript submitted for publication to Journal of Computer Behavior.

Dick, W., Carey, L., & Carey, J.O. (2005). *The systematic design of instruction* (6th ed.). New York: Allyn and Bacon.

DiPietro, M., Ferdig, R., Boyer, J., & Black, E. (2007). Towards a framework for understanding electronic educational gaming. *Journal of Educational Multimedia and Hypermedia, 16*(3), 225-248.

Duncan, T. E. (1999). *An introduction to latent variable growth curve modeling: Concepts, issues, and applications*. Mahwah, N.J: Lawrence Erlbaum Associates.

Dweck, C. S. (1999). *Self theories: Their role in motivation, personality, and development*. Philadelphia: Psychology Press.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*, 109-132.

French, R. M., & Cleeremans, A. (Eds.), (2002). *Implicit learning and consciousness: An empirical, philosophical and computational consensus in the making*. New York: Taylor & Francis.

Gee, J. P. (2003). *What video games have to teach us about learning*. New York: Palgrave Macmillian.

Gwilliam, L. R., & Betz, N. E. (2001). Validity of measures of math- and science-related self-efficacy for African-Americans and European Americans. *Journal of Career Assessment*, *9*(3), 261-281.

Hart, G., & Rudman, W B. (1999). *New world coming: American security in the 21st century–Major themes and implications*. Washington, DC: U.S. Commission on National Security.

Hirumi, A., Appelman, B., Rieber, L., & Van Eck, R. (2010). Preparing Instructional Designers for Game-Based Learning: Part 2. *TechTrends. 54*(4), 19-27.

Hoadley, C.M. (2004). Methodological alignment in design-based research. *Educational Psychologist*, *39*, 203-212.

Holladay, C.L., & Quiñones, M.A. (2003). Practice variability and transfer of training: The role of self-efficacy generality. *Journal of Applied Psychology*, *88*, 1094-1103.

Holland, J. L. (1996). Exploring careers with a typology: What we have learned and some new directions. *American Psychologist*, *51*, 397-406.

Jonassen, D. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? *Educational Technology Research and Development*. 39 (3). 5-14.

Kato, P.M., Cole, S.W., Bradlyn, A.S., & Pollock, B.H. (2008). A video game improves behavioral outcomes in adolescents and young adults with cancer: A randomized trial. *Pediatrics*, *122*, 305-317.

Kuhn, D. (2000). Metacognitive development. *Current Directions in Psychological Science, 9*(5), 178-181.

Lee, J., & Wong, K. (2004). The impact of accountability on racial and socioeconomic equity: Considering both school resources and achievement outcomes. *American Educational Research Journal*, *41*, 797-832.

Lenhart, A., Kahne, J., Middaugh, E., Macgill, A. R., Evans, C., & Vitak, J. (2008). Teens, video games, and civics. Retrieved from Pew Internet & American Life Project: http://pewInternet.org/pdfs/PIP_Teens_Games_and _Civics_Report_FINAL.pdf

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance [Monograph]. *Journal of Vocational Behavior, 45,* 79-122.

Lent, R. W., Larkin, K.C., & Brown, S.D. (1989). Relation of self-efficacy to inventoried vocational interests. *Journal of Vocational Behavior, 34,* 279-288.

Marcel, C. (2010, March 14). Message posted to Facebook: http://www.facebook.com

Marzano, R. J. (1998). *A theory-based meta-analysis of research on instruction*. Aurora, CO: Mid-Continent Regional Educational Laboratory.

Matlin, M. (2005). *Cognition* (6th ed.), Hoboken, NJ: John Wiley & Sons.

Messick, S. (1989). Validity. In Linn, R. (Ed.), *Educational measurement* (3rd ed.) (pp. 13-103). New York: American Council on Education and Macmillan.

Morrison, G., Ross, S., & Kemp, J. E. (2004). *Designing effective instruction* (4th ed.). New York: John Wiley & Sons.

Nacke, L., & Lindley, C. (2008). Boredom, immersion, flow–A pilot study investigating player experience. In *Proceedings of the IADIS Gaming 2008: Design for Engaging Experience and Social Interaction* (pp. 103-107). Amsterdam, The Netherlands: IADIS Press.

National Science Board. (2010). *Science and engineering indicators 2010*. Arlington, VA: National Science Foundation (NSB 10-01).

National Science Foundation (NSF). (2002). *The science and engineering workforce: Realizing America's potential*. Retrieved from http://www.nsf.gov/nsb/documents /2003 /nsb0369/nsb0369.pdf

Nauta, M.N. (2010). The development, evolution, and status of Holland's theory of vocational personalities: Reflections and Future Directions for counseling psychology. *Journal of Counseling Psychology. 57* (1), 11-22.

O'Leary, S., Diepenhorst, L., Churley-Strom, R., & Magrane, D. (2005). Educational games in an obstetrics and gynecology core curriculum. *American Journal of Obstetrics and Gynecology, 193*, 1848-1851.

O'Sullivan, C., & Weiss, A. (1998). *Student work and teacher practices in science: A report on what students know and can do.* Jessup, MD: National Center for Educational Statistics.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*(4), 543-578.

Papert, S. (1998, June). Does easy do it? Children, games, and learning. *Game Developer*. Retrieved from http://www.papert.org/articles/Doeseasydoit.html

Pashler, H., Johnston, J., & Ruthruff, E. (2001). Attention and performance. *Annual Review of Psychology*, *52*, 629-651.

Peng, W. (2008). The meditational role of identification in the relationship between experience mode and self-efficacy: Enactive role-playing versus passive observation. *CyberPsychology & Behavior*, *11*(6), 649-652.

Peng, W. (2009). Design and evaluation of a computer game to promote a healthy diet for young adults. *Health Communication*, *24*, 115-127.

Petticrew, M., & Roberts, H. (2006). *Systematic reviews in the social sciences: A practical guide*. Oxford: Blackwell.

Plude, D.J., Enns, J.T., & Brodeur, D. (1994). The development of selective attention: A life-span overview. *Acta Psychologica*, *86*, 227-272.

Poels, K., de Kort, Y. D., & IJsselstein, W. (2007). "It is always a lot of fun!": Exploring dimensions of digital game experience using focus group methodology. In *Proceedings of the 2007 Conference on Future Play* (pp. 83-89). Toronto, Canada: ACM.

Prensky, M. (2005). Complexity matters. *Educational Technology*, *45*(4).

Pugh, K. J., & Bergin, D. A. (2006). Motivational influences on transfer. *Educational Psychologist*, *41*, 147-160.

Reber, A.S. (1993). *Implicit learning and tacit knowledge: An essay on the cognitive unconscious*. Oxford: Oxford University Press.

Rieber, L.P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research and Development*, *44*(2), 43-58.

Rouse, R., III. (2005). *Game design: Theory and practice* (2nd ed.). Plano, TX: Wordware Publishing.

Salen, K., & Zimmermann, E. (2004). *Rules of play: Game design fundamentals.* Cambridge, MA: MIT Press.

Sanford, K., & Madill, L. (2007). Understanding the power of new literacies through video game splay and design. *Canadian Journal of Education, 30*(2), 432-456.

Saxe, G., & Guberman, S. (1998). Studying mathematics learning in collective activity. *Learning and Instruction*, *8*(6), 489.

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. 2003. Evaluating the fit of equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research Online*, *28*(2): 23-74.

Schmitt, N. (1996). Uses and abuses of coefficient alpha. *Psychological Assessment, 8*, 350-353.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: 1. Detection, search, and attention. *Psychological Review*, *84*, 1-66.

Scruggs, T.E., & Mastropieri, M.A. (2007). Science learning in special education: The case for constructed versus instructed learning. *Exceptionality*, *15,* 57-74.

Seger, C. A. (1994). Implicit learning. *Psychological Bulletin*, *115*(2), 163-196.

Sheridan, T. B. (2007). *Attention and its allocation: Fragments of a model*. In Kramer, A.F., Wiegmann, D.A., & Kirlik, A. (Eds.), *Attention: From theory to practice* (pp. 16-26). New York: Oxford University Press.

Smith, P.L., & Ragan, T.J. (2005). *Instructional design* (3rd ed.). Hoboken, NJ: John Wiley & Sons.

Spokane, A. R. (1985). A Review of research on person-environment congruence in Holland's theory of careers. *Journal of Vocational Behavior, 26*, 306-343.

Thomas, R., Cahill, J., & Santilli, L. (1997). Using an interactive computer game to increase skill and self-efficacy regarding safer sex negotiation: Field test results. *Health Education & Behavior*, *24*(1), 71-86.

Tinsley, H. E. A., & Tinsley, D. J. (1987). Uses of factor analysis in counseling psychology research. *Journal of Counseling Psychology*, *34*, 414-424.

Tracey, T. J. G., & Ward, C. C. (1998). The structure of children's interests and competence perceptions. *Journal of Counseling Psychology*, *45*, 290-303.

Van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless. *EDUCAUSE Review*, *41*, 16-30.

Wickens, C. D. (2002). Multiple resources and performance prediction. *Theoretical Issues in Ergonomic Science, 3*(2), 159-177.

Wickens, C. D. (2007). Attention to attention and its applications: A concluding view. In Kramer, A.F., Wiegmann, D. A., & Kirlik, A. (Eds.), *Attention: From theory to practice* (pp. 239-249). New York: Oxford University Press.

Widaman, K. F., Ferrer, E., & Conger, R. (2010). Factorial invariance within longitudinal structural equation models: Measuring the same construct across time. *Child Development Perspectives*, *4*, 10–18.

Wigfield, A. L., & Eccles, J. S. (2001). *Development of achievement motivation*. San Diego, CA: Academic Press.

APPENDIX A

DEGREE OF FLOW SURVEY

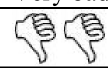
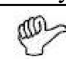
MY GAMES: Please indicate how you felt while playing the game for each of the items:

		Not at all	A little	Somewhat	Fairly	Extremely
		0 Stars	★	★★	★★★	★★★★
1.	I was interested in the game's story					
2.	I felt like I was doing well in the game					
3.	I felt bored with the game					
4.	I was impressed with the game					
5.	I forgot everything around me					
6.	I felt like it was too hard for me					
7.	I was ready to do something else					
8.	I felt irritated					
9.	I felt like I was able to do it					
10.	I felt completely wrapped up in the game					
11.	I felt happy					
12.	I felt tested					
13.	I felt excited					
14.	I felt good					

APPENDIX B

INVESTIGATIVE SELF-EFFICACY (ISE) SURVEY

MY STRENGTHS: Please indicate how good you are at each of the activities below:

	Very bad	Bad	Okay	Good	Very Good
					
1. Understanding how things work					
2. Taking things apart					
3. Watching a show like CIS, Science Show about exploring answers to questions					
4. Searching the internet to find answers to questions					
5. Mixing things together to see what happens					

APPENDIX C

```
Mplus VERSION 5.2
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INPUT INSTRUCTIONS

  title:
    RQ1 Performance
   DATA: FILE IS 20100823.txt;
   VARIABLE:
           NAMES ARE Uid c1 c2
          perf1 geq1 ise1
          perf2 geq2 ise2
          perf3 geq3 ise3
          perf4 geq4 ise4;

  !data across 4 days
           USEVARIABLES c1 perf1 perf2 perf3 perf4 ;

  MISSING ARE .;
   ANALYSIS:        ITERATIONS=15000;
     !  type = basic;     !Pattern of Missing Data
    model:
  !Data across 4 days
     perf_i perf_s | perf1@0 perf2@1 perf3@2 perf4@3;

       perf_s on c1;



  OUTPUT: SAMPSTAT TECH4 MODINDICES(3) STANDARDIZED;



INPUT READING TERMINATED NORMALLY




RQ1 Performance

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                          47

Number of dependent variables                                    4
Number of independent variables                                  1
Number of continuous latent variables                            2
```

Observed dependent variables

Continuous
PERF1 PERF2 PERF3 PERF4

Observed independent variables
C1

Continuous latent variables
PERF_I PERF_S

Estimator	ML
Information matrix	OBSERVED
Maximum number of iterations	15000
Convergence criterion	0.500D-04
Maximum number of steepest descent iterations	20
Maximum number of iterations for H1	2000
Convergence criterion for H1	0.100D-03

Input data file(s)
20100823.txt

Input data format FREE

SUMMARY OF DATA

Number of missing data patterns 14

COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value 0.100

PROPORTION OF DATA PRESENT

Covariance Coverage

	PERF1	PERF2	PERF3	PERF4	C1
PERF1	0.574				
PERF2	0.447	0.617			
PERF3	0.447	0.489	0.574		
PERF4	0.468	0.489	0.511	0.617	
C1	0.574	0.617	0.574	0.617	1.000

SAMPLE STATISTICS

ESTIMATED SAMPLE STATISTICS

Means

	PERF1	PERF2	PERF3	PERF4	C1
1	-0.018	0.171	0.365	0.337	-0.085

Covariances

	PERF1	PERF2	PERF3	PERF4	C1
PERF1	0.235				
PERF2	0.049	0.310			
PERF3	0.051	0.189	0.325		
PERF4	-0.015	0.089	0.168	0.324	
C1	0.004	0.282	0.317	0.507	2.078

Correlations

	PERF1	PERF2	PERF3	PERF4	C1
PERF1	1.000				
PERF2	0.180	1.000			
PERF3	0.185	0.595	1.000		
PERF4	-0.054	0.281	0.516	1.000	
C1	0.006	0.352	0.386	0.618	1.000

MAXIMUM LOG-LIKELIHOOD VALUE FOR THE UNRESTRICTED (H1) MODEL IS -156.940

THE MODEL ESTIMATION TERMINATED NORMALLY

```
TESTS OF MODEL FIT

Chi-Square Test of Model Fit

          Value                              9.877
          Degrees of Freedom                     8
          P-Value                           0.2738

Chi-Square Test of Model Fit for the Baseline Model

          Value                             35.271
          Degrees of Freedom                    10
          P-Value                           0.0001

CFI/TLI

          CFI                                0.926
          TLI                                0.907

Loglikelihood

          H0 Value                        -161.878
          H1 Value                        -156.940

Information Criteria

          Number of Free Parameters             10
          Akaike (AIC)                     343.756
          Bayesian (BIC)                   362.257
          Sample-Size Adjusted BIC         330.894
            (n* = (n + 2) / 24)

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.071
          90 Percent C.I.                    0.000  0.194
          Probability RMSEA <= .05           0.357

SRMR (Standardized Root Mean Square Residual)

          Value                              0.109



MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 PERF_I   |
    PERF1              1.000      0.000    999.000    999.000
```

```
   PERF2              1.000      0.000    999.000    999.000
   PERF3              1.000      0.000    999.000    999.000
   PERF4              1.000      0.000    999.000    999.000

 PERF_S   |
   PERF1              0.000      0.000    999.000    999.000
   PERF2              1.000      0.000    999.000    999.000
   PERF3              2.000      0.000    999.000    999.000
   PERF4              3.000      0.000    999.000    999.000

 PERF_S   ON
   C1                 0.064      0.030      2.139      0.032

 C1       WITH
   PERF_I             0.089      0.121      0.740      0.459

 Means
   PERF_I             0.040      0.083      0.487      0.626

 Intercepts
   PERF1              0.000      0.000    999.000    999.000
   PERF2              0.000      0.000    999.000    999.000
   PERF3              0.000      0.000    999.000    999.000
   PERF4              0.000      0.000    999.000    999.000
   PERF_S             0.119      0.042      2.839      0.005

 Variances
   PERF_I             0.038      0.042      0.898      0.369

 Residual Variances
   PERF1              0.215      0.069      3.104      0.002
   PERF2              0.225      0.074      3.028      0.002
   PERF3              0.188      0.069      2.741      0.006
   PERF4              0.115      0.069      1.665      0.096
   PERF_S             0.008      0.009      0.923      0.356
```

```
Mplus VERSION 5.2
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INPUT INSTRUCTIONS

  title:
    RQ1 Degree of Flow
   DATA: FILE IS 20100823.txt;
    VARIABLE:
           NAMES ARE Uid c1 c2
```

```
          perf1 geq1 ise1
          perf2 geq2 ise2
          perf3 geq3 ise3
          perf4 geq4 ise4;
  !data across 4 days
           USEVARIABLES c1 geq1 geq2 geq3 geq4 ;

  MISSING ARE .;
   ANALYSIS:        ITERATIONS=15000;
     !  type = basic;     !Pattern of Missing Data
    model:
  !Data across 4 days
      geq_i  geq_s | geq1@0 geq2@1 geq3@2 geq4@3;

       geq_s on c1;

  geq_s@.0001;
   OUTPUT: SAMPSTAT TECH4 MODINDICES(3) STANDARDIZED;



INPUT READING TERMINATED NORMALLY




RQ1 Degree of Flow

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                          47

Number of dependent variables                                    4
Number of independent variables                                  1
Number of continuous latent variables                            2

Observed dependent variables

  Continuous
   GEQ1        GEQ2        GEQ3        GEQ4

Observed independent variables
   C1

Continuous latent variables
   GEQ_I       GEQ_S


Estimator                                                       ML
Information matrix                                        OBSERVED
```

Maximum number of iterations	15000
Convergence criterion	0.500D-04
Maximum number of steepest descent iterations	20
Maximum number of iterations for H1	2000
Convergence criterion for H1	0.100D-03

Input data file(s)
20100823.txt

Input data format FREE

SUMMARY OF DATA

Number of missing data patterns 11

COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value 0.100

PROPORTION OF DATA PRESENT

Covariance Coverage

	GEQ1	GEQ2	GEQ3	GEQ4	C1
GEQ1	0.766				
GEQ2	0.638	0.830			
GEQ3	0.660	0.723	0.872		
GEQ4	0.617	0.638	0.723	0.766	
C1	0.766	0.830	0.872	0.766	1.000

SAMPLE STATISTICS

ESTIMATED SAMPLE STATISTICS

Means

	GEQ1	GEQ2	GEQ3	GEQ4	C1
1	2.632	2.608	2.417	2.502	-0.085

Covariances

	GEQ1	GEQ2	GEQ3	GEQ4	C1
GEQ1	0.590				
GEQ2	0.293	1.006			
GEQ3	0.445	0.271	0.611		
GEQ4	0.350	0.374	0.349	0.546	
C1	0.172	0.031	0.212	0.106	2.078

Correlations

	GEQ1	GEQ2	GEQ3	GEQ4	C1
GEQ1	1.000				
GEQ2	0.381	1.000			
GEQ3	0.742	0.346	1.000		
GEQ4	0.616	0.504	0.604	1.000	
C1	0.156	0.022	0.188	0.099	1.000

MAXIMUM LOG-LIKELIHOOD VALUE FOR THE UNRESTRICTED (H1) MODEL IS -241.275

THE MODEL ESTIMATION TERMINATED NORMALLY

TESTS OF MODEL FIT

Chi-Square Test of Model Fit

Value	5.511
Degrees of Freedom	9
P-Value	0.7877

Chi-Square Test of Model Fit for the Baseline Model

Value	44.392
Degrees of Freedom	10
P-Value	0.0000

CFI/TLI

```
          CFI                                    1.000
          TLI                                    1.113

Loglikelihood

          H0 Value                            -244.030
          H1 Value                            -241.275

Information Criteria

          Number of Free Parameters                  9
          Akaike (AIC)                         506.060
          Bayesian (BIC)                       522.711
          Sample-Size Adjusted BIC             494.484
            (n* = (n + 2) / 24)

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                               0.000
          90 Percent C.I.                        0.000  0.109
          Probability RMSEA <= .05               0.842

SRMR (Standardized Root Mean Square Residual)

          Value                                  0.089


MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 GEQ_I    |
    GEQ1               1.000      0.000    999.000    999.000
    GEQ2               1.000      0.000    999.000    999.000
    GEQ3               1.000      0.000    999.000    999.000
    GEQ4               1.000      0.000    999.000    999.000

 GEQ_S    |
    GEQ1               0.000      0.000    999.000    999.000
    GEQ2               1.000      0.000    999.000    999.000
    GEQ3               2.000      0.000    999.000    999.000
    GEQ4               3.000      0.000    999.000    999.000

 GEQ_S    ON
    C1                -0.003      0.029     -0.092      0.927

 C1       WITH
    GEQ_I              0.154      0.170      0.906      0.365
```

```
 Means
    GEQ_I              2.623      0.114     22.983      0.000

 Intercepts
    GEQ1               0.000      0.000    999.000    999.000
    GEQ2               0.000      0.000    999.000    999.000
    GEQ3               0.000      0.000    999.000    999.000
    GEQ4               0.000      0.000    999.000    999.000
    GEQ_S             -0.060      0.038     -1.601      0.109

 Variances
    GEQ_I              0.376      0.103      3.644      0.000

 Residual Variances
    GEQ1               0.185      0.077      2.388      0.017
    GEQ2               0.748      0.193      3.883      0.000
    GEQ3               0.220      0.072      3.051      0.002
    GEQ4               0.205      0.073      2.810      0.005
    GEQ_S              0.000      0.000    999.000    999.000
```

```
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08/24/2010   4:46 PM

INPUT INSTRUCTIONS

  title:
   RQ1 Investigative self-efficacy model
   DATA: FILE IS 20100823.txt;
   VARIABLE:
           NAMES ARE Uid c1 c2
          perf1 geq1 ise1
          perf2 geq2 ise2
          perf3 geq3 ise3
          perf4 geq4 ise4;

  !data across 4 days
           USEVARIABLES ise1 ise2 ise3 ise4 c1;

  MISSING ARE .;
   ANALYSIS:        ITERATIONS=15000;
      ! type = basic;     !Pattern of Missing Data
    model:
  !Data across 4 days
```

```
      ise_i ise_s | ise1@0 ise2@1 ise3@2 ise4@3;

      ise_s on c1;

  OUTPUT: SAMPSTAT TECH4 MODINDICES(3) STANDARDIZED;



INPUT READING TERMINATED NORMALLY




RQ1 Investigative self-efficacy model

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                          47

Number of dependent variables                                    4
Number of independent variables                                  1
Number of continuous latent variables                            2

Observed dependent variables

  Continuous
   ISE1        ISE2        ISE3        ISE4

Observed independent variables
   C1

Continuous latent variables
   ISE_I       ISE_S


Estimator                                                       ML
Information matrix                                        OBSERVED
Maximum number of iterations                                 15000
Convergence criterion                                    0.500D-04
Maximum number of steepest descent iterations                   20
Maximum number of iterations for H1                           2000
Convergence criterion for H1                             0.100D-03

Input data file(s)
  20100823.txt

Input data format  FREE


SUMMARY OF DATA
```

Number of missing data patterns 9

COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value 0.100

PROPORTION OF DATA PRESENT

Covariance Coverage

	ISE1	ISE2	ISE3	ISE4	C1
ISE1	0.766				
ISE2	0.638	0.851			
ISE3	0.660	0.745	0.872		
ISE4	0.638	0.638	0.745	0.787	
C1	0.766	0.851	0.872	0.787	1.000

SAMPLE STATISTICS

ESTIMATED SAMPLE STATISTICS

Means

	ISE1	ISE2	ISE3	ISE4	C1
1	3.868	4.153	4.074	4.197	-0.085

Covariances

	ISE1	ISE2	ISE3	ISE4	C1
ISE1	0.479				
ISE2	0.266	0.620			
ISE3	0.227	0.220	0.561		
ISE4	0.191	0.064	0.371	0.514	
C1	0.316	0.205	0.251	0.250	2.078

```
           Correlations
              ISE1          ISE2          ISE3          ISE4
C1
              ________      ________      ________      ________
________
 ISE1          1.000
 ISE2          0.489         1.000
 ISE3          0.437         0.374         1.000
 ISE4          0.384         0.113         0.692         1.000
 C1            0.316         0.181         0.233         0.242
1.000


     MAXIMUM LOG-LIKELIHOOD VALUE FOR THE UNRESTRICTED (H1) MODEL
IS    -231.259


THE MODEL ESTIMATION TERMINATED NORMALLY



TESTS OF MODEL FIT

Chi-Square Test of Model Fit

          Value                              5.729
          Degrees of Freedom                     8
          P-Value                           0.6775

Chi-Square Test of Model Fit for the Baseline Model

          Value                             45.696
          Degrees of Freedom                    10
          P-Value                           0.0000

CFI/TLI

          CFI                                1.000
          TLI                                1.080

Loglikelihood

          H0 Value                        -234.123
          H1 Value                        -231.259

Information Criteria

          Number of Free Parameters             10
          Akaike (AIC)                     488.247
```

```
          Bayesian (BIC)                        506.748
          Sample-Size Adjusted BIC              475.384
            (n* = (n + 2) / 24)

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                                0.000
          90 Percent C.I.                         0.000  0.135
          Probability RMSEA <= .05                0.746

SRMR (Standardized Root Mean Square Residual)

          Value                                   0.161



MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 ISE_I    |
    ISE1               1.000      0.000    999.000    999.000
    ISE2               1.000      0.000    999.000    999.000
    ISE3               1.000      0.000    999.000    999.000
    ISE4               1.000      0.000    999.000    999.000

 ISE_S    |
    ISE1               0.000      0.000    999.000    999.000
    ISE2               1.000      0.000    999.000    999.000
    ISE3               2.000      0.000    999.000    999.000
    ISE4               3.000      0.000    999.000    999.000

 ISE_S    ON
    C1                -0.011      0.032     -0.357      0.721

 C1       WITH
    ISE_I              0.278      0.148      1.880      0.060

 Means
    ISE_I              3.925      0.099     39.835      0.000

 Intercepts
    ISE1               0.000      0.000    999.000    999.000
    ISE2               0.000      0.000    999.000    999.000
    ISE3               0.000      0.000    999.000    999.000
    ISE4               0.000      0.000    999.000    999.000
    ISE_S              0.085      0.042      2.039      0.041

 Variances
    ISE_I              0.216      0.077      2.800      0.005
```

```
 Residual Variances
    ISE1               0.238      0.084      2.833      0.005
    ISE2               0.474      0.128      3.691      0.000
    ISE3               0.228      0.068      3.324      0.001
    ISE4               0.100      0.081      1.238      0.216
    ISE_S              0.024      0.013      1.759      0.079
```

```
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INPUT INSTRUCTIONS

  title:
   RQ2 Performance
    DATA: FILE IS 20100823.txt;
    VARIABLE:
           NAMES ARE Uid c1 c2
          perf1 geq1 ise1
          perf2 geq2 ise2
          perf3 geq3 ise3
          perf4 geq4 ise4;

  !data across 4 days
           USEVARIABLES c2 perf1 perf2 perf3 perf4;

  MISSING ARE .;
   ANALYSIS:        ITERATIONS=15000;
     !  type = basic;     !Pattern of Missing Data

    model:
  !Data across 4 days
     perf_i  perf_s | perf1@0 perf2@1 perf3@2 perf4@3;

       perf_s on c2;


  OUTPUT: SAMPSTAT TECH4 MODINDICES(3) STANDARDIZED;



INPUT READING TERMINATED NORMALLY
```

```
RQ2 Performance

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                          47

Number of dependent variables                                    4
Number of independent variables                                  1
Number of continuous latent variables                            2

Observed dependent variables

  Continuous
   PERF1       PERF2       PERF3       PERF4

Observed independent variables
   C2

Continuous latent variables
   PERF_I      PERF_S


Estimator                                                       ML
Information matrix                                        OBSERVED
Maximum number of iterations                                 15000
Convergence criterion                                    0.500D-04
Maximum number of steepest descent iterations                   20
Maximum number of iterations for H1                           2000
Convergence criterion for H1                             0.100D-03

Input data file(s)
  20100823.txt

Input data format  FREE


SUMMARY OF DATA

     Number of missing data patterns            14


COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value   0.100


     PROPORTION OF DATA PRESENT


           Covariance Coverage
```

	PERF1	PERF2	PERF3	PERF4	C2
PERF1	0.574				
PERF2	0.447	0.617			
PERF3	0.447	0.489	0.574		
PERF4	0.468	0.489	0.511	0.617	
C2	0.574	0.617	0.574	0.617	1.000

SAMPLE STATISTICS

ESTIMATED SAMPLE STATISTICS

Means

	PERF1	PERF2	PERF3	PERF4	C2
1	-0.144	0.211	0.471	0.395	-0.298

Covariances

	PERF1	PERF2	PERF3	PERF4	C2
PERF1	0.235				
PERF2	0.100	0.318			
PERF3	0.107	0.192	0.336		
PERF4	-0.003	0.112	0.163	0.301	
C2	0.235	-0.046	-0.053	-0.040	0.550

Correlations

	PERF1	PERF2	PERF3	PERF4	C2
PERF1	1.000				
PERF2	0.367	1.000			
PERF3	0.382	0.588	1.000		
PERF4	-0.012	0.362	0.513	1.000	
C2	0.656	-0.110	-0.124	-0.099	1.000

```
     MAXIMUM LOG-LIKELIHOOD VALUE FOR THE UNRESTRICTED (H1) MODEL
IS    -117.792


THE MODEL ESTIMATION TERMINATED NORMALLY



TESTS OF MODEL FIT

Chi-Square Test of Model Fit

          Value                             24.687
          Degrees of Freedom                     8
          P-Value                           0.0018

Chi-Square Test of Model Fit for the Baseline Model

          Value                             51.058
          Degrees of Freedom                    10
          P-Value                           0.0000

CFI/TLI

          CFI                                0.594
          TLI                                0.492

Loglikelihood

          H0 Value                        -130.136
          H1 Value                        -117.792

Information Criteria

          Number of Free Parameters             10
          Akaike (AIC)                     280.272
          Bayesian (BIC)                   298.774
          Sample-Size Adjusted BIC         267.410
            (n* = (n + 2) / 24)

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.211
          90 Percent C.I.                    0.119  0.308
          Probability RMSEA <= .05           0.005

SRMR (Standardized Root Mean Square Residual)

          Value                              0.161
```

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
PERF_I |				
PERF1	1.000	0.000	999.000	999.000
PERF2	1.000	0.000	999.000	999.000
PERF3	1.000	0.000	999.000	999.000
PERF4	1.000	0.000	999.000	999.000
PERF_S |				
PERF1	0.000	0.000	999.000	999.000
PERF2	1.000	0.000	999.000	999.000
PERF3	2.000	0.000	999.000	999.000
PERF4	3.000	0.000	999.000	999.000
PERF_S ON				
C2	-0.167	0.048	-3.488	0.000
C2 WITH				
PERF_I	0.184	0.051	3.591	0.000
Means				
PERF_I	-0.080	0.075	-1.072	0.284
Intercepts				
PERF1	0.000	0.000	999.000	999.000
PERF2	0.000	0.000	999.000	999.000
PERF3	0.000	0.000	999.000	999.000
PERF4	0.000	0.000	999.000	999.000
PERF_S	0.152	0.041	3.734	0.000
Variances				
PERF_I	0.153	0.057	2.668	0.008
Residual Variances				
PERF1	0.052	0.039	1.346	0.178
PERF2	0.233	0.073	3.197	0.001
PERF3	0.156	0.064	2.426	0.015
PERF4	0.190	0.096	1.977	0.048
PERF_S	0.012	0.010	1.175	0.240

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```
INPUT INSTRUCTIONS

  title:
    RQ2 Degree of Flow
    DATA: FILE IS 20100823.txt;
   VARIABLE:
           NAMES ARE Uid c1 c2
          perf1 geq1 ise1
          perf2 geq2 ise2
          perf3 geq3 ise3
          perf4 geq4 ise4;

  !data across 4 days
           USEVARIABLES c2 geq1 geq2 geq3 geq4 ;

  MISSING ARE .;
   ANALYSIS:        ITERATIONS=15000;
     !  type = basic;     !Pattern of Missing Data
    model:
  !Data across 4 days
      geq_i  geq_s | geq1@0 geq2@1 geq3@2 geq4@3;

       geq_s on c2;

  geq_s@.0001

   OUTPUT: SAMPSTAT TECH4 MODINDICES(3) STANDARDIZED;



INPUT READING TERMINATED NORMALLY




RQ2 Degree of Flow

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                          47

Number of dependent variables                                    4
Number of independent variables                                  1
Number of continuous latent variables                            2

Observed dependent variables

  Continuous
   GEQ1        GEQ2        GEQ3        GEQ4
```

```
Observed independent variables
   C2

Continuous latent variables
   GEQ_I       GEQ_S


Estimator                                                    ML
Information matrix                                     OBSERVED
Maximum number of iterations                              15000
Convergence criterion                                 0.500D-04
Maximum number of steepest descent iterations                20
Maximum number of iterations for H1                        2000
Convergence criterion for H1                          0.100D-03

Input data file(s)
  20100823.txt

Input data format  FREE


SUMMARY OF DATA

     Number of missing data patterns           11


COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value   0.100


     PROPORTION OF DATA PRESENT


           Covariance Coverage
              GEQ1          GEQ2          GEQ3          GEQ4
C2
              ________      ________      ________      ________
________
 GEQ1           0.766
 GEQ2           0.638         0.830
 GEQ3           0.660         0.723         0.872
 GEQ4           0.617         0.638         0.723         0.766
 C2             0.766         0.830         0.872         0.766
1.000


SAMPLE STATISTICS
```

ESTIMATED SAMPLE STATISTICS

Means

	GEQ1	GEQ2	GEQ3	GEQ4	C2
1	2.634	2.588	2.426	2.508	-0.298

Covariances

	GEQ1	GEQ2	GEQ3	GEQ4	C2
GEQ1	0.593				
GEQ2	0.293	1.000			
GEQ3	0.445	0.270	0.607		
GEQ4	0.339	0.360	0.339	0.531	
C2	-0.008	0.150	0.015	0.055	0.550

Correlations

	GEQ1	GEQ2	GEQ3	GEQ4	C2
GEQ1	1.000				
GEQ2	0.380	1.000			
GEQ3	0.742	0.346	1.000		
GEQ4	0.604	0.494	0.597	1.000	
C2	-0.015	0.202	0.025	0.101	1.000

MAXIMUM LOG-LIKELIHOOD VALUE FOR THE UNRESTRICTED (H1) MODEL IS -209.711

THE MODEL ESTIMATION TERMINATED NORMALLY

TESTS OF MODEL FIT

Chi-Square Test of Model Fit

Value 6.702

```
          Degrees of Freedom                         9
          P-Value                               0.6681

Chi-Square Test of Model Fit for the Baseline Model

          Value                                 45.011
          Degrees of Freedom                        10
          P-Value                               0.0000

CFI/TLI

          CFI                                    1.000
          TLI                                    1.073

Loglikelihood

          H0 Value                            -213.062
          H1 Value                            -209.711

Information Criteria

          Number of Free Parameters                  9
          Akaike (AIC)                         444.124
          Bayesian (BIC)                       460.776
          Sample-Size Adjusted BIC             432.548
            (n* = (n + 2) / 24)

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                               0.000
          90 Percent C.I.                        0.000  0.132
          Probability RMSEA <= .05               0.742

SRMR (Standardized Root Mean Square Residual)

          Value                                  0.096



MODEL RESULTS

                                                        Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 GEQ_I    |
    GEQ1               1.000      0.000    999.000    999.000
    GEQ2               1.000      0.000    999.000    999.000
    GEQ3               1.000      0.000    999.000    999.000
    GEQ4               1.000      0.000    999.000    999.000

 GEQ_S    |
```

```
    GEQ1               0.000      0.000    999.000    999.000
    GEQ2               1.000      0.000    999.000    999.000
    GEQ3               2.000      0.000    999.000    999.000
    GEQ4               3.000      0.000    999.000    999.000

 GEQ_S    ON
    C2                 0.023      0.043      0.533      0.594

 C2       WITH
    GEQ_I              0.011      0.081      0.135      0.893

 Means
    GEQ_I              2.628      0.113     23.242      0.000

 Intercepts
    GEQ1               0.000      0.000    999.000    999.000
    GEQ2               0.000      0.000    999.000    999.000
    GEQ3               0.000      0.000    999.000    999.000
    GEQ4               0.000      0.000    999.000    999.000
    GEQ_S             -0.053      0.039     -1.350      0.177

 Variances
    GEQ_I              0.369      0.101      3.639      0.000

 Residual Variances
    GEQ1               0.189      0.080      2.368      0.018
    GEQ2               0.740      0.191      3.871      0.000
    GEQ3               0.225      0.073      3.060      0.002
    GEQ4               0.200      0.072      2.775      0.006
    GEQ_S              0.000      0.000    999.000    999.000
```

```
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INPUT INSTRUCTIONS

  title:
   RQ2 Investigative self-efficacy model
   DATA: FILE IS 20100823.txt;
    VARIABLE:
           NAMES ARE Uid c1 c2
          perf1 geq1 ise1
          perf2 geq2 ise2
          perf3 geq3 ise3
          perf4 geq4 ise4;

  !data across 4 days
           USEVARIABLES ise1 ise2 ise3 ise4 c2;
```

```
  MISSING ARE .;
   ANALYSIS:        ITERATIONS=15000;
      ! type = basic;     !Pattern of Missing Data
    model:
  !Data across 4 days
      ise_i ise_s | ise1@0 ise2@1 ise3@2 ise4@3;

      ise_s on c2;

  OUTPUT: SAMPSTAT TECH4 MODINDICES(3) STANDARDIZED;



INPUT READING TERMINATED NORMALLY




RQ2 Investigative self-efficacy model

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                          47

Number of dependent variables                                    4
Number of independent variables                                  1
Number of continuous latent variables                            2

Observed dependent variables

  Continuous
   ISE1        ISE2        ISE3        ISE4

Observed independent variables
   C2

Continuous latent variables
   ISE_I       ISE_S


Estimator                                                       ML
Information matrix                                        OBSERVED
Maximum number of iterations                                 15000
Convergence criterion                                    0.500D-04
Maximum number of steepest descent iterations                   20
Maximum number of iterations for H1                           2000
Convergence criterion for H1                             0.100D-03

Input data file(s)
  20100823.txt

Input data format  FREE
```

SUMMARY OF DATA

Number of missing data patterns 9

COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value 0.100

PROPORTION OF DATA PRESENT

Covariance Coverage

	ISE1	ISE2	ISE3	ISE4	C2
ISE1	0.766				
ISE2	0.638	0.851			
ISE3	0.660	0.745	0.872		
ISE4	0.638	0.638	0.745	0.787	
C2	0.766	0.851	0.872	0.787	1.000

SAMPLE STATISTICS

ESTIMATED SAMPLE STATISTICS

Means

	ISE1	ISE2	ISE3	ISE4	C2
1	3.887	4.134	4.091	4.210	-0.298

Covariances

	ISE1	ISE2	ISE3	ISE4	C2
ISE1	0.496				
ISE2	0.301	0.612			
ISE3	0.193	0.221	0.544		
ISE4	0.158	0.081	0.354	0.496	
C2	0.069	0.141	0.155	0.064	0.550

Correlations

	ISE1	ISE2	ISE3	ISE4	C2
ISE1	1.000				
ISE2	0.546	1.000			
ISE3	0.372	0.383	1.000		
ISE4	0.318	0.146	0.681	1.000	
C2	0.131	0.243	0.283	0.122	1.000

MAXIMUM LOG-LIKELIHOOD VALUE FOR THE UNRESTRICTED (H1) MODEL IS -199.877

THE MODEL ESTIMATION TERMINATED NORMALLY

TESTS OF MODEL FIT

Chi-Square Test of Model Fit

Value	7.144
Degrees of Freedom	8
P-Value	0.5211

Chi-Square Test of Model Fit for the Baseline Model

Value	45.952
Degrees of Freedom	10
P-Value	0.0000

CFI/TLI

CFI	1.000
TLI	1.030

Loglikelihood

H0 Value	-203.449
H1 Value	-199.877

Information Criteria

Number of Free Parameters	10
Akaike (AIC)	426.898
Bayesian (BIC)	445.399
Sample-Size Adjusted BIC	414.035
(n* = (n + 2) / 24)	

```
RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.000
          90 Percent C.I.                    0.000  0.159
          Probability RMSEA <= .05           0.605

SRMR (Standardized Root Mean Square Residual)

          Value                              0.135



MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 ISE_I    |
    ISE1               1.000      0.000    999.000    999.000
    ISE2               1.000      0.000    999.000    999.000
    ISE3               1.000      0.000    999.000    999.000
    ISE4               1.000      0.000    999.000    999.000

 ISE_S    |
    ISE1               0.000      0.000    999.000    999.000
    ISE2               1.000      0.000    999.000    999.000
    ISE3               2.000      0.000    999.000    999.000
    ISE4               3.000      0.000    999.000    999.000

 ISE_S    ON
    C2                 0.000      0.054      0.008      0.994

 C2       WITH
    ISE_I              0.105      0.071      1.486      0.137

 Means
    ISE_I              3.948      0.099     39.810      0.000

 Intercepts
    ISE1               0.000      0.000    999.000    999.000
    ISE2               0.000      0.000    999.000    999.000
    ISE3               0.000      0.000    999.000    999.000
    ISE4               0.000      0.000    999.000    999.000
    ISE_S              0.081      0.046      1.765      0.078

 Variances
    ISE_I              0.200      0.073      2.749      0.006

 Residual Variances
    ISE1               0.276      0.095      2.916      0.004
    ISE2               0.430      0.118      3.654      0.000
    ISE3               0.224      0.069      3.238      0.001
    ISE4               0.115      0.086      1.332      0.183
    ISE_S              0.022      0.014      1.568      0.117
```

```
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INPUT INSTRUCTIONS

  title:
   RQ2 Structural Model
   DATA: FILE IS 20100823.txt;
    VARIABLE:
           NAMES ARE Uid c1 c2
          perf1 geq1 ise1
          perf2 geq2 ise2
          perf3 geq3 ise3
          perf4 geq4 ise4;

  !data across 4 days
           USEVARIABLES perf1 geq1 ise1 perf2 geq2 ise2
            perf3 geq3 ise3 perf4 geq4 ise4 c2;

  MISSING ARE .;
   ANALYSIS:        ITERATIONS=15000;
     !  type = basic;     !Pattern of Missing Data
    model:
  !Data across 4 days
      ise_i ise_s | ise1@0 ise2@1 ise3@2 ise4@3;
      geq_i geq_s | geq1@0 geq2@1 geq3@2 geq4@3;
      perf_i perf_s | perf1@0 perf2@1 perf3@2 perf4@3;

     !structural model
     ise_s  on geq_s;  !GEQ ->ISE

     ise_s on perf_s;  !PERF ->ISE Intercept

     geq_s  perf_s on c2;

  geq_s@.0001;
  ise_s@.0001;


  OUTPUT: SAMPSTAT TECH4 MODINDICES(3) STANDARDIZED;
```

```
INPUT READING TERMINATED NORMALLY



RQ2 Structural Model

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                          47

Number of dependent variables                                   12
Number of independent variables                                  1
Number of continuous latent variables                            6

Observed dependent variables

  Continuous
   PERF1       GEQ1        ISE1        PERF2       GEQ2        ISE2
   PERF3       GEQ3        ISE3        PERF4       GEQ4        ISE4

Observed independent variables
   C2

Continuous latent variables
   ISE_I       ISE_S       GEQ_I       GEQ_S       PERF_I
PERF_S


Estimator                                                       ML
Information matrix                                        OBSERVED
Maximum number of iterations                                 15000
Convergence criterion                                    0.500D-04
Maximum number of steepest descent iterations                   20
Maximum number of iterations for H1                           2000
Convergence criterion for H1                             0.100D-03

Input data file(s)
  20100823.txt

Input data format  FREE


SUMMARY OF DATA

     Number of missing data patterns           23


COVARIANCE COVERAGE OF DATA
```

Minimum covariance coverage value 0.100

PROPORTION OF DATA PRESENT

Covariance Coverage

	PERF1	GEQ1	ISE1	PERF2	GEQ2
PERF1	0.574				
GEQ1	0.574	0.766			
ISE1	0.574	0.766	0.766		
PERF2	0.447	0.532	0.532	0.617	
GEQ2	0.489	0.638	0.638	0.596	0.830
ISE2	0.489	0.638	0.638	0.617	0.830
PERF3	0.447	0.511	0.511	0.489	0.511
GEQ3	0.468	0.660	0.660	0.574	0.723
ISE3	0.468	0.660	0.660	0.574	0.723
PERF4	0.468	0.553	0.553	0.489	0.511
GEQ4	0.468	0.617	0.617	0.511	0.638
ISE4	0.468	0.638	0.638	0.511	0.638
C2	0.574	0.766	0.766	0.617	0.830

Covariance Coverage

	ISE2	PERF3	GEQ3	ISE3	PERF4
ISE2	0.851				
PERF3	0.511	0.574			
GEQ3	0.745	0.574	0.872		
ISE3	0.745	0.574	0.872	0.872	
PERF4	0.511	0.511	0.596	0.596	0.617
GEQ4	0.638	0.511	0.723	0.723	0.617
ISE4	0.638	0.511	0.745	0.745	0.617

C2	0.851	0.574	0.872	0.872	0.617

Covariance Coverage

	GEQ4	ISE4	C2
GEQ4	0.766		
ISE4	0.766	0.787	
C2	0.766	0.787	1.000

SAMPLE STATISTICS

ESTIMATED SAMPLE STATISTICS

Means

	PERF1	GEQ1	ISE1	PERF2	GEQ2
1	-0.118	2.699	3.932	0.208	2.585

Means

	ISE2	PERF3	GEQ3	ISE3	PERF4
1	4.140	0.423	2.427	4.094	0.334

Means

	GEQ4	ISE4	C2
1	2.524	4.222	-0.298

Covariances

	PERF1	GEQ1	ISE1	PERF2	GEQ2
PERF1	0.274				
GEQ1	-0.120	0.594			
ISE1	-0.011	0.089	0.488		
PERF2	0.102	0.101	-0.104	0.330	

GEQ2	0.184	0.180	-0.084	0.187	0.967
ISE2	0.047	-0.014	0.292	-0.005	0.217
PERF3	0.099	-0.063	-0.019	0.215	0.110
GEQ3	-0.122	0.349	0.031	0.131	0.270
ISE3	0.010	0.048	0.134	0.071	0.046
PERF4	-0.002	0.015	0.050	0.096	0.187
GEQ4	-0.084	0.346	-0.033	0.065	0.281
ISE4	-0.025	0.139	0.146	0.108	-0.193
C2	0.225	-0.019	0.079	-0.059	0.112

Covariances

	ISE2	PERF3	GEQ3	ISE3	PERF4
ISE2	0.600				
PERF3	0.143	0.336			
GEQ3	0.159	0.075	0.557		
ISE3	0.222	0.106	0.158	0.539	
PERF4	0.260	0.173	0.138	0.147	0.364
GEQ4	0.008	-0.052	0.319	0.151	0.147
ISE4	0.011	-0.001	0.135	0.341	0.016
C2	0.132	-0.041	0.020	0.160	0.005

Covariances

	GEQ4	ISE4	C2
GEQ4	0.538		
ISE4	0.212	0.516	
C2	0.034	0.057	0.550

Correlations

PERF1 GEQ1 ISE1 PERF2 GEQ2

PERF1	1.000				
GEQ1	-0.297	1.000			
ISE1	-0.030	0.165	1.000		
PERF2	0.338	0.228	-0.259	1.000	
GEQ2	0.358	0.237	-0.123	0.331	1.000
ISE2	0.115	-0.023	0.540	-0.012	0.285
PERF3	0.328	-0.141	-0.046	0.647	0.193
GEQ3	-0.313	0.606	0.059	0.307	0.368
ISE3	0.026	0.086	0.262	0.170	0.063
PERF4	-0.007	0.033	0.119	0.277	0.315
GEQ4	-0.217	0.612	-0.064	0.155	0.389
ISE4	-0.067	0.250	0.292	0.261	-0.273
C2	0.580	-0.033	0.153	-0.138	0.154

Correlations

	ISE2	PERF3	GEQ3	ISE3	PERF4
ISE2	1.000				
PERF3	0.319	1.000			
GEQ3	0.276	0.175	1.000		
ISE3	0.390	0.249	0.288	1.000	
PERF4	0.557	0.495	0.306	0.333	1.000
GEQ4	0.013	-0.121	0.582	0.280	0.333
ISE4	0.020	-0.003	0.252	0.647	0.036
C2	0.230	-0.095	0.036	0.295	0.011

Correlations

	GEQ4	ISE4	C2
GEQ4	1.000		
ISE4	0.402	1.000	
C2	0.063	0.106	1.000

```
     MAXIMUM LOG-LIKELIHOOD VALUE FOR THE UNRESTRICTED (H1) MODEL
IS    -366.829


THE MODEL ESTIMATION TERMINATED NORMALLY



TESTS OF MODEL FIT

Chi-Square Test of Model Fit

          Value                              142.280
          Degrees of Freedom                      70
          P-Value                             0.0000

Chi-Square Test of Model Fit for the Baseline Model

          Value                              252.634
          Degrees of Freedom                      78
          P-Value                             0.0000

CFI/TLI

          CFI                                  0.586
          TLI                                  0.539

Loglikelihood

          H0 Value                          -437.969
          H1 Value                          -366.829

Information Criteria

          Number of Free Parameters               32
          Akaike (AIC)                       939.938
          Bayesian (BIC)                     999.143
          Sample-Size Adjusted BIC           898.778
            (n* = (n + 2) / 24)

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                             0.148
          90 Percent C.I.                      0.113  0.183
          Probability RMSEA <= .05             0.000

SRMR (Standardized Root Mean Square Residual)

          Value                                0.185
```

```
MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 ISE_I    |
    ISE1               1.000      0.000    999.000    999.000
    ISE2               1.000      0.000    999.000    999.000
    ISE3               1.000      0.000    999.000    999.000
    ISE4               1.000      0.000    999.000    999.000

 ISE_S    |
    ISE1               0.000      0.000    999.000    999.000
    ISE2               1.000      0.000    999.000    999.000
    ISE3               2.000      0.000    999.000    999.000
    ISE4               3.000      0.000    999.000    999.000

 GEQ_I    |
    GEQ1               1.000      0.000    999.000    999.000
    GEQ2               1.000      0.000    999.000    999.000
    GEQ3               1.000      0.000    999.000    999.000
    GEQ4               1.000      0.000    999.000    999.000

 GEQ_S    |
    GEQ1               0.000      0.000    999.000    999.000
    GEQ2               1.000      0.000    999.000    999.000
    GEQ3               2.000      0.000    999.000    999.000
    GEQ4               3.000      0.000    999.000    999.000

 PERF_I   |
    PERF1              1.000      0.000    999.000    999.000
    PERF2              1.000      0.000    999.000    999.000
    PERF3              1.000      0.000    999.000    999.000
    PERF4              1.000      0.000    999.000    999.000

 PERF_S   |
    PERF1              0.000      0.000    999.000    999.000
    PERF2              1.000      0.000    999.000    999.000
    PERF3              2.000      0.000    999.000    999.000
    PERF4              3.000      0.000    999.000    999.000

 ISE_S    ON
    GEQ_S              9.459      8.686      1.089      0.276
    PERF_S             0.834      0.775      1.075      0.282

 GEQ_S    ON
    C2                 0.015      0.026      0.594      0.552
```

PERF_S ON				
C2	-0.169	0.048	-3.519	0.000
GEQ_I WITH				
ISE_I	0.101	0.061	1.668	0.095
PERF_I WITH				
ISE_I	0.050	0.046	1.097	0.273
GEQ_I	0.006	0.059	0.096	0.923
C2 WITH				
ISE_I	0.104	0.071	1.467	0.142
GEQ_I	0.016	0.076	0.214	0.831
PERF_I	0.185	0.052	3.544	0.000
Means				
ISE_I	3.951	0.100	39.555	0.000
GEQ_I	2.627	0.113	23.225	0.000
PERF_I	-0.085	0.075	-1.135	0.257
Intercepts				
PERF1	0.000	0.000	999.000	999.000
GEQ1	0.000	0.000	999.000	999.000
ISE1	0.000	0.000	999.000	999.000
PERF2	0.000	0.000	999.000	999.000
GEQ2	0.000	0.000	999.000	999.000
ISE2	0.000	0.000	999.000	999.000
PERF3	0.000	0.000	999.000	999.000
GEQ3	0.000	0.000	999.000	999.000
ISE3	0.000	0.000	999.000	999.000
PERF4	0.000	0.000	999.000	999.000
GEQ4	0.000	0.000	999.000	999.000
ISE4	0.000	0.000	999.000	999.000
ISE_S	0.500	0.732	0.683	0.494
GEQ_S	-0.058	0.037	-1.565	0.117
PERF_S	0.148	0.041	3.644	0.000
Variances				
ISE_I	0.199	0.071	2.810	0.005
GEQ_I	0.377	0.102	3.682	0.000
PERF_I	0.161	0.059	2.731	0.006
Residual Variances				
PERF1	0.046	0.044	1.050	0.294
GEQ1	0.180	0.075	2.397	0.017
ISE1	0.283	0.094	3.007	0.003
PERF2	0.230	0.072	3.189	0.001
GEQ2	0.763	0.196	3.887	0.000
ISE2	0.416	0.114	3.642	0.000
PERF3	0.146	0.061	2.414	0.016
GEQ3	0.218	0.072	3.053	0.002

ISE3	0.211	0.067	3.138	0.002
PERF4	0.208	0.097	2.147	0.032
GEQ4	0.196	0.071	2.775	0.006
ISE4	0.161	0.092	1.745	0.081
ISE_S	0.000	0.000	999.000	999.000
GEQ_S	0.000	0.000	999.000	999.000
PERF_S	0.012	0.011	1.060	0.289

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GRANT WRITING

2010. USDA-NIFA. *Engaging Middle School Youth in Development and Optimization of Two Nutrition Education Media Products to Improve Nutrition Knowledge and Energy Balance*. (Funded)

PUBLICATIONS

Debose Columbus, Y. (2006). Relax! Entice! Engage. Learning Center Exchange [Online]. Available: http://www.learningassistance.com/2006/september/trainbyexample.html

Debose, Y. R., Hobbs, A., & Erdos, P. (1996). Graphs Having No Short Even Cycles. *Congressus Numerantium*, *121*, 243-253.

PRESENTATIONS

Icke, A., & Debose Columbus, Y. (2010). Moodle: Lessons Learned, presented at Texas Distance Learning Association in Houston, TX.

Debose Columbus, Y., & Cifuentes, L. (2009). A Case for Stealth Educational Games, presented at Association for Educational Communications and Technology in Louisville, KY.